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RACE, TYPE, AND ETHNIC GROUP IN ANCIENT GREECE

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INTRODUCTION

IN studying populations the human biologist uses symbols to simplify various realities as closely as possible. These simplifications include dynamic generalizations of all the human beings in any defined group, of their biological (gene distributions and linkages ideally), environmental (geography, society, and diet), and historical backgrounds, and of the interplay of these factors as the social biology of the group.

The group studied may be a race, defined by Hooton (1932, pp. 397-398) as

> "a great division of mankind, the members of which, though individually varying, are characterized as a group by a certain combination of morphological and metrical features, principally non-adaptive, which have been derived from their common descent.
>
> "A primary race is one which has been modified only by the operation of evolutionary factors . . . .
>
> "A secondary or composite race is . . . . a . . . . stabilized combination . . . . effected by a long-continued intermixture of two or more primary races within an area of relative isolation."

Since relative unity in genes and in geographical distribution defines race only such separate groups as mongoloid, negroid, white, australoid, and bushman can be handled as biologically real though scarcely homogeneous units. Dobzhansky (1944, p. 252) defines races more dynamically as "populations differing in the incidence of certain genes, but actually exchanging or potentially able to exchange genes across whatever boundaries (usually geographic) separate them." Hence such relatively isolated ethnic groups as Greenland Eskimos, Ainu, Lapps, or Andamenese form real local races (*cf.* Dahlberg, 1942, p. 380), in contrast to most ethnic groups, such as Swedes, Brazilians, Javanese, or Masai, which appear to contain a large number of competing "local races" so blending by gene exchange (*cf.* Dobzhansky, 1944, pp. 254, 262) that they are no longer precisely traceable, nor sufficiently fused to form a single new local race. Thus no anthropologist today would use "Nordic" to name a real local race[1]. Such a category may have descriptive usefulness as a "type." But the combination of traits involved has no real stability, and can never be isolated as a genetic-geographic unit even in the distant past and in changed form, since McCown and Keith's data (1939, pp. 13-14, 371-373) show that even such distinct subspecies as modern and Neanderthal man combined to produce new and highly changeable blends as soon as the Palaeolithic population began to increase in the distribution area of the modern white race (Coon, 1939, pp. 16-86).

The most logical group for the human biologist to study is the breeding unit, generally equated, too broadly, with ethnic group. "Ἔθνος (Liddell and Scott, 1889, p. 412) means "a number of people living together, a company, a nation, people, tribe." It does not imply any common descent or necessary genetic connection between people in the group, although there are average morphological differences of racial (i. e., genetic) origin between many ethnic groups. And though an ethnic group as a social unit reaches a certain slight genetic individuality, which is overstressed in the American dictionary definition (Neilson, ed. Webster's Dictionary, 1937, p. 877), the group is hardly ever genetically homozygous enough to form a race, and after immigrations can include a majority of strangers.

[1] *Cf.* Washburn, 1943, p. 75. Yet in spite of Coon's (1939) outline of genetic and historical forces continually re-forming a complex web of *potential* local races or types, Benedict and Weltfish (1943, pp. 10-11) use Ripley's Nordic, Alpine, Mediterranean subdivisions as the "stocks" which make up the white race. Since this pamphlet as a whole puts the race problem in ideal perspective, the oversimplification is used laudably.

Since differences between ethnic groups come from genetic together with historical, environmental, and social selective forces, anthropologists use ethnic units to work out racial variety and race history[2]. But when the biometric school[3] and other anthropologists forgot pioneer concepts[4] like those of T. H. Huxley and defined race as ethnic group[5] they let either racists or the general public continue to equate Nordics with Nazis, Mediterraneans with Italians, or Mediterraneans with Jews, no matter how scurrilous, unreal, or just plain inaccurate such equations are. This confusion allowed such terms as Irish race, Jewish race, or Greek race to persist, though all this was the opposite of these anthropologists' intentions. Thus the physical anthropologist or human biologist must be most careful to recognize the dynamic genetic (racial) compositeness of any ethnic group.

Theoretically use of gene frequency differences to contrast breeding groups would avoid these difficulties. And though this is impossible at present, frequencies of observed phenotypic characters are indispensable supplements to the imaginary average individual as a descriptive stereotype, which is a convenient symbol for intergroup comparison and for estimates of statistical certainty and degree of phenotypic difference between groups.

To understand human development in relation to society such effects of environment as the recent increase in body size (Bowles, 1932), or the selective changes resulting from migration (Shapiro, 1939, p. 200-201; Coon, 1939, pp. 7-8) must be recorded precisely. The average individual is a good generalization for this. But it is implausible that either the average individual or gene frequency charts can be of exclusive value for study of social biology. Here the variety of individuals performing different roles and derived from diverse origins is an essential factor, as suggested by variability of whites contrasted with aboriginal Australian (Schreiner, 1939, p. 126) or New World pre-Columbian populations (Stewart, 1943), and by cyclic changes in variability (Angel, 1944). Variety stresses differences between individuals, most clearly generalized in types which represent the central tendencies of the most frequently occurring combinations of morphological traits. Types arbi-

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[2] *Cf.* Morant, 1925, 1928; Coon, 1939; Howells, 1941; Angel, 1944.

[3] E. g., Pearson and Davin, 1924, p. 332; Morant, 1928, p. 306.

[4] See von Eickstedt's (1937, p. 48) history of these concepts.

[5] Ashley Montagu (1942, pp. 44-46) quotes J. Huxley and Haddon to this general effect, but later (1945, p. 32) discusses ethnic group as primarily a cultural unit.

trarily crystallize the points of greatest consistency in the phenotypic continuum of a genetically mixed ethnic group. And though they are no less imaginary symbols and no more realities than the average individual, types allow a picture of social dynamics in biological terms[6].

Thus the usefulness of any generalization of population depends on what we want to know about the group. In addition to census data and data on social and other selective mechanisms, we need answers to more wholly biological questions. These include: (1) the various origins of the population, (2) its chronological changes in relation to migrations, selection, diet, and climate, (3) the physical distinctiveness of its subgroups[7], (4) the kind and degree of association (presumably culturally maintained) between physique and behaviour, and (5) the social significance of individual diversity. Detailed comparison of type dynamics in male and female ancient Greeks will make clearer what kinds of generalization are best fitted to solve these five problems.

TYPES

The Hellenic people knew themselves to be ethnically composite and could name many of the pre-Classical peoples who contributed to the amalgam, such as Dorians, Hylleis or Heraclids, Achaeans, Danaans, Ionians, Pelasgians. Obviously ancient Greeks belong to the white race. But they are not physically homogeneous. And the relation of their ethnic and racial diversities is involved.

In an earlier study (Angel, 1944), male skeletons of ancient Greeks were divided into types to give greater vividness to physical change during the last five thousand years. Six types were synthesized from 23 mutual resemblance subgroups each composed of about a dozen skulls which resembled one another closely in comparisons made between standardized photographs of all norms of the skull. The types were

[6] *Cf.* Hooton, 1937, pp. 187-211. Types may have a plastic genetic reality, since in studies like those of Coon they behave like potential local races. Snell (1931) describes a definite skull type in the house mouse linked with tail, ear, and pigment features. But no breeding experiments have yet tested how far types represent multiple effects of single genes or genetic linkage tendencies. And the strong probability that types can shed light on historical interconnections and on racial origins of ethnic groups needs testing. Beyond the psychological conditioning relative to social standards which everyone's physique imposes on him and the related association between "temperament" and physical type (Sheldon, 1940, 1942), no genetically determined behaviour patterns can be associated with types.

[7] *Cf.* Morant, 1940, pp. 75-77.

validated by their near identities to various non-Greek groups each representing a distinct tendency[8] within the white race; by their divergence from the total series and from each other; by their relative homogeneity; and by the predictions of period to period change derivable from their frequencies. Hence types probably do represent genetic realities to some degree, despite artificiality. Their degree of overlap approximates that expected from real local races. And they aid in study of origins, correlation of racial with cultural change, and estimates of individual differences.

But weaknesses in the types, especially their inflexibility, demand further testing in a comparison of type morphology and chronological sequence in period groups among females with that already worked out among ancient Greek males (Angel, 1944). This will clarify types, add to understanding of population dynamics in Greece, and point to better methods of generalizing individual peculiarities[9].

As seen in Table 1, the mean male type deviation from the total series averages 106.4 per cent of the female type deviation from the total series of ancient Greek females. The latter is 2.02 mm. and 1.74 index units for twelve measurements and seven indices. And although the female types are closer to non-Greek series than to the total series, they are not much closer to the corresponding male types than they are to the non-Greek series. Their deviation from the correponding male types, after correction for sex differences found between the male and female

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[8] These series were chosen as relatively homogeneous ethnic groups each dominated by a single (genetic) trend and almost a potential local race. There was no material defining a morphologically isolated "Alpine," "Dinaric," or "Mediterranean" genetically "pure" type.

[9] Travelling fellowships from Harvard supported the field work. For help in tedious skeletal repair and assistance with statistical records I am deeply indebted to my wife. Anthropological and classical archaeological authorities of Harvard, of the American School of Classical Studies at Athens, of the Athenian Agora Excavations, of the Greek Archaeological Service (Ministry of Religions and National Education), National Museum, and Anthropological Museum (at the Greek National University Medical School), and of the U. S. National Museum and American Museum of Natural History made it possible for me to study both ancient and modern inhabitants of Greece. The long basic statistical reduction of the various period groups and total group was carried out by the statistical laboratory staff of Harvard's Peabody Museum. The technique of measuring and observation is that of the anthropological laboratory under Dr. E. A. Hooton, and is defined in the publication of the Greek males (1944). The use of standardized observations to describe morphology which cannot be measured has been developed by Hooton.

TABLE 1

Mean measurements and indices of ancient Greek female morphological types

CHARACTER	TYPE A Basic White		TYPE B Classic Mediterranean		TYPE D Nordic-Iranian		TYPE F Dinaric-Mediterranean		TYPE E Mixed Alpine		TYPE C Alpine	
	Mean	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Horiz. circumf.	*506.1	26	*489.7	21	501.9	8	501.6	11	502.5	12	497.0	16
Length	*180.9	33	174.0	28	*181.4	17	174.7	12	175.3	15	*170.3	22
Breadth	135.9	33	*131.7	27	132.9‡	16	140.1	12	139.5	16	*141.0	24
Auricular ht.	113.4	31	110.4	26	115.3	15	112.2	12	112.7	11	113.6	21
Minimum frontal	93.0	24	91.6‡	22	92.9	12	92.7	11	*94.8	12	93.2	18
Basion-nasion	*98.0	14	*94.2	18	97.1	11	95.8	11	94.0‡	6	94.5	15
Nasalia angle	59.6	7	52.8	10	54.0	6	52.7	7	59.3	4	61.5	4
Bizygomatic	121.5	13	*118.2	16	123.1	10	*129.3	11	121.8	5	122.2	11
Bigonial	90.0	3	90.7	9	92.2‡	9	96.3‡	9	95.0	4	93.8	8
Upper face ht.	64.7	12	63.7	16	66.9	11	*69.4	11	*61.6	5	63.3	12
Chin height	27.4‡	8	28.4	12	29.1	10	*32.7	7	28.5	4	28.1	9
Nose height	47.7	12	47.4	17	49.2	12	*51.5	11	45.5	6	47.6	11
Nose breadth	22.5‡	10	24.2‡	15	23.5	12	23.6	11	23.0	6	22.8	11
Cranial index	*75.1	33	*75.8	26	*73.3‡	16	*80.1	12	*79.6	15	*83.1	22
Length-aur. ht.	62.7	31	63.5	25	63.4	14	64.3	12	63.7	10	*66.3	19
Breadth-aur. ht.	83.4	31	*84.2	24	*86.0‡	13	*80.2	12	80.9	10	*79.7	21
Fronto-parietal	68.3	24	69.9	21	69.9	11	66.7	11	68.2	15	*65.9	18
Upper facial	53.6	9	54.0	14	54.4	10	54.3	10	50.5	5	51.8	9
Nasal index	47.9	10	50.7‡	15	48.0	11	46.2	11	51.2	6	48.0	11
Left orbital	82.4‡	10	91.0	12	88.6	8	85.9	11	85.8	5	87.8	11
Stature in cm.	156.5	4	151.2	5	154.2	4	157.4	6	157.9	1	153.8	6

Stature in cm.	156.5	4	151.2	5	154.2	4	157.4	6	157.9	1	153.8	6

TABLE 1 *(continued)*

Mean measurements and indices of ancient Greek female mophological types

CHARACTER	TYPE A Basic White		TYPE B Classic Mediterranean		TYPE D Nordic-Iranian		TYPE F Dinaric-Mediterranean		TYPE E Mixed Alpine		TYPE C Alpine	
	Mean	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Deviations from total: Metric	1.83		2.68		1.58		2.63		1.76		1.66	
Indicial	1.49		1.63		1.78		1.70		1.57		2.29	
Relative deviation from male types	103.6%		56.7%		91.3%		77.8%		90.4%		51.3%	
Male deviation from total	110.5%		93.5%		107.4%		94.7%		103.4%		128.7%	
Mean "Deviation Ratio"	Chalc. Megiddo: 98.3%		Siwah: 73.1%		Hissar: 84.4%				Illyrians: 100.9%		Carinthians: 62.5%	
	Ch. Sardinia: 118.1%		Spanish: 61.9%		Franks: 70.6%						Cypriotes: 126.3%	

Note: Values deviating from the total female series by from 2.5 to 3.0 times the p. e. are starred, by 3.0 to 4.0 italicized, by 4.0 or more times the p. e. both starred and italicized. Values deviating significantly (3.0 or more times the p. e.) from the means of the male types corrected for the sex difference (as found between male and female total series) are marked ♯. Deviations of male from female types, of male types from the total series, and of outside groups from female types ("Deviation Ratio") are all expressed as percentages of the female type deviations from the total series.

total series (Angel, 1944, Table 1), is 78.5 per cent of their deviation from the total series of females. Thus male and female types diverge in closely similar directions from their respective total series. But the females diverge 6 or 7 per cent less strongly, and approach identity with male types less closely than expected. And though most of this discrepancy (if not all of it) results from small samples, some of the statistically significant divergences of female from male types are worth examining.

The female Basic White (type A) has a long, large, rather low, rugged pentagonoid or rhomboid vault, with low forehead, definitely marked browridges, profile flattenings along the roof and at lambda, projecting occiput, pentagonoid norma occipitalis with some basal norrowing, and strong mastoids (by female standards). Markedly low and only slightly tilted orbits are the only striking features of the small face, which shows incipient prognathism and strong chin. So far this coincides with the males, and like the males the female Basic Whites are close to Chalcolithic Palestinians from Megiddo[10] and slightly resemble Chalcolithic Sardinians. But females of this type are closer to the total series and farther from the males than are other female types. They differ from the male type (Angel, 1944, Figure 5) significantly in shallower chins, narrower noses, and lower orbits. And except for their orbits, which exaggerate the male upper facial trend, the females lack almost all the ruggedness of the male face and nose, an exaggeration of normal lower face sex differences.

The Mediterranean female (type B) vault is relatively narrow, small, and gracile, slightly angular, with relatively wide and vertical forehead above weak browridges, an arched vertex, slight lambdoid flattening, prominent well-rounded occiput, and pentagonoid rear view with rounded roof. The face is pinched and inverted trapezoid in outline, but not weak. Well-modelled cheekbones next deep canine fossae border significantly high rhomboid orbits. The broad mesorrhine nose has fairly salient nasalia. And the slight downward tilt of mandibular corpus fits consistent incipient prognathism and only slight projection of pointed chin. Mediterranean females diverge further from the total series than do the males, and agree extremely well with Siwah Libyans, Modern Spanish, and the male Mediterranean type (Angel, 1944, Figure 6).

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[10] Authorities for non-Greek series will not be listed here since they are given in the descriptions of the males (Angel, 1944).

Yet the females differ from the males in significantly broader noses and foreheads, with an impression of greater facial crudity which seems real (although small numbers of females discouraged calculation of observation percentages to check such impressions). Thus relative to the males, female Mediterranean and Basic White types seem to exchange lower face traits to some extent, and the Mediterranean orbit, nose, and jaw details suggest Iranian traits.

The Nordic-Iranian (type D) female skull has a long, narrow, high vault, fairly well filled, ellipsoid or rounded pentagonoid, with clearcut browridges, high forehead, rounded profile, deep occiput, strong mastoids, and rounded roof with scarcely convex sidewalls in rear view. Chin squareness rather than jowl breadth gives an impression of rectangularity to an otherwise long oval face. Orbits are fairly high[11] with average slope, cheekbones and nose intermediate, and jaw large but compressed with triangular chin of average projection and depth[12]. This does not disagree with the males. But female Nordic-Iranians are almost as far from the males as from the total series, though definitely closer to North Iranians from Hissar III (Krogman, 1940, Tables IX and X, Figures 3 and 5) and to Franks (Matthäus, 1940). Significantly greater female linearity simply carries the male Nordic Iranian vault pattern (Angel, 1944, Figure 7) to a greater extreme. But the females have more angular vaults, significantly narrower gonia, and shadow rather than repeat the facial distinctiveness of the males. Virtual lack of "Iron Age Nordics" (type D 1) among the females connects with this. And overlaps with Basic White, Mediterranean, and Dinaric-Mediterranean female types are clear.

The female Dinaric-Mediterranean (type F) just brachycrane vault is wide and byrsoid-sphenoid, with strongly sloping, pinched forehead, profile curve rising to vertex far back before bending into angled and non-prominent occiput, pointed mastoids, shallow glenoid fossae, and scarcely perceptible low gabling and rounded sides in rear view. The face is big and massive, wide relative to the forehead, and long hexa-

[11] Compared to low male orbital index of 82.56 (incorrectly copied as 83.56 in Table 3, p. 344, of Angel, 1944).

[12] In contrast to male Nordic-Iranians (whose significant excess in symphysis height over the total series was not indicated in Table 3, p. 344, of Angel, 1944, because of a subtractive error whose correction also raises the mean deviation of male Nordic-Iranians by .03 mm.).

gonal in spite of broad jowls. Flaring and "spidery" cheekbones bound rhomboid orbits. A long narrow nose combines long and salient nasalia with weak nasion depression. And a large orthognathous mouth with tilted occlusal plane fits a large, muscular, and deep jaw with triangular and non-projecting chin. These females are not comparable with too linear Lower Egyptians nor too small-faced Cypriotes, yet differ little from the Dinaric-Mediterranean male pattern (Angel, 1944, Figure 8). Only in excessive jowl breadth is their divergence from the males significant. But the females are too massive (overlapping Mixed Alpines), too low-headed, and facially too convex and too rectangular, showing a virtual exchange of traits with Nordic-Iranians in the lower face especially.

The Mixed Alpine (type E) female vault is a blunt ovoid (varying from sphenoid to rhomboid) short-based high mesocrane form, well filled, with capacious vertical forehead, smooth profile curve marked by relatively vertical lambdoid flattening, small mastoids, and horseshoe shaped rear view. The rounded square face is very low, flat, with large orbits. The short concave nose with weak nasion depression is not significantly chaemerrhine[13]. The wide and shallow mouth and jaw region is orthognathous. The females are adequately similar to male Mixed Alpines and to a small series of Carniola Iron Age Illyrians[14], with poor approximation to Bessarabian Scythians. The short female skull base is the only significant difference from the males (Angel, 1944, Figure 9), and the low female face confirms a statistically uncertain male trend. But the females lack the huge-vaulted subtype (E 1). Overlap with the Alpine type and with the Basic White type is expected.

Alpine (type C) females have sphenoid-ovoid, almost square, vault form, brachycrane, short-based, with relatively narrow, low, full forehead, rounded profile except for lessened upper occipital curvature, clear-cut nuchal lines, and squat bulging rear view. The face is low, small, flat, with short hexagonal to round outline, anteriorly thrusting cheekbones, rounded rhomboid orbits, concave and non-salient nose, orthognathous and average mouth and jaw with median and prominent chin. Though the females agree precisely with male Alpines (Angel, 1944, Figure 10),

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[13] And not significantly shorter than the Mixed Alpine male nasal index of 49.65 (incorrectly copied as 48.65 in Table 3, p. 345, of Angel, 1944).

[14] Crania in Peabody Museum not yet published. For males, see Angel, 1944, Table 5.

show close similarity to Greifenberg Carinthians, and deviate very significantly from the total series, they are quantitatively less deviant than the males from the total series. Poor approximation to Bronze Age East Cypriotes links with evident Mediterranean minorities among this group's females. The females show no significant differences from the males and show the same European and Eastern Alpine variety in face and occiput. Overlap with type F is barely perceptible, but in such traits as base shortness and nose and face lowness some exchange of traits with Mixed Alpines is clear.

The female type frequencies in Table 2 agree well with the successive period samples, despite inadequate size of these samples. None of the significant differences marked in Table 2 is valid, since zero percentages reduce the probable error of the difference disproportionately. But since they suit the males, the following racial changes are plausible: (1) excess of Nordic-Iranians in the Middle Bronze Age linked with reduction in Mediterraneans; (2) excess of Dinaric-Mediterraneans in the Roman period; (3) possible excess of Mediterraneans in Byzantine times. Lack of female Nordic-Iranians in third millennium B. C. and Roman period samples presumably results entirely from small samples and is compensated by the overlap with Dinaric-Mediterraneans. Though not significantly contrasting with the males, the relative lack of female type change from Late Bronze through Classical times is probably biologically important.

The female Neolithic plus Early Bronze Age sample contains only a single Neolithic calva with 13 Early Helladic skulls. The average pre-Greek female has a broad rhomboid (-ovoid) vault, almost brachycrane, fairly high, with strikingly narrow base and relatively narrow forehead compared to the total series of females. The small orthognathous face is significantly narrow relative to the vault. Excess of a strongly-bossed variety of Mediterranean plus slight "dinaricisation" explicable by Alpine modifications fits this average description. Significant differences from the male sample in three indices all spring from significantly greater female head breadth, connected in turn with lack of Neolithic females (linear Mediterranean or Iranian?) and stress on Mediterraneans subjectively identifiable among males also as strongly resembling Lower Egyptians[18]. (See Table 3.)

The Middle Bronze Age female vault averages strikingly longer, larger, and broader-based than the pre-Greek sample, more ovoid, doli-

[18] *Cf.* Woo (1930), Morant (1925), and Sergi's *"rhomboides aegpytiacus."*

TABLE 2

Percentage frequencies of six female morphological types in seven period groups

TYPE	NEOL.-E. H.	M. H.-L. H. II	L. H. III	EARLY IRON	CLASSIC	ROMAN	BYZANTINE	TOTAL SERIES
C: Alpine	14.3	7.7	22.2	18.8	18.5	12.5	22.2	17.29
E: Mixed Alpine	14.3	7.7	11.1	12.5	11.1	12.5	0	11.28
F: Dinaric Mediterranean	7.1	0	3.7	12.5	11.1	31.3	0	9.02
D: Nordic-Iranian	0‡	38.5	14.8	18.7	14.8	0‡	11.1	13.54
B: Classic Mediterranean	35.7	*7.7	22.2	25.0	29.7	12.5	*44.5	24.06
A: Basic White	28.6	38.4	26.0	12.5	14.8	31.2	22.2	24.81
Number skulls	14	13	27	16	37	16	9	133
Deviation from previous period	6.1	16.1	12.1	5.6	2.3	12.7	17.6	

Note: Deviations from values of the preceding period and from male type frequencies are marked as in Table 3. Frequencies for the Submycenaean Cephallenians, omitted here, are close to the Late Helladic III percentages.

chocrane, with lower and more sloping forehead, flatter sidewalls, and deeper occiput. But the face is lower, especially subnasally, is more hexagonal and shorter-nosed, with striking upper facial pinching seen in narrowed nasalia. These features fit Nordic-Iranian plus Basic White type dominance, with subtle Alpinoid traits in face rather than vault. The overwhelming divergence from the males, in vault linearity, clearly reflects lack of Alpine and hybrid Alpine individuals important among the males toward the end of the period especially (L. H. I - II). But since the divergence also shows linear Basic White influence, the female Middle Bronze Age vault recalls the male vault of the preceding period.

The female L. H. III sample, from the height and decline of the Mycenaean period, combines a smaller, shorter, short-based, low mesocrane, pentagonoid vault with a slightly higher and more protrusive face. This suits a stable blend of Alpine with the long-headed types, and agrees perfectly with male averages, differing significantly only in greater prognathism where the females exaggerate a definite male trend. If the slight Mycenaean female excesses of Alpine and Nordic-Iranian deserve mention they stress resemblance to the preceding male sample and confirm the extent to which these are blended with Basic White in the Mycenaean male sample.

The Homeric period Cephallenian females (Angel, 1943, Table 2) omitted from this paper, are slightly lower and longer-vaulted and less Alpine than Mycenaean females, but less distinctive and insular than the males.

The Isthmian Greek females of Early Iron Age (Submycenaean, Protogeometric, and Geometric) date have possibly longer, more capacious rounded ovoid vaults than the Mycenaean females, with flatter forehead and vertex, combined with more orthognathous, broader, and more hexagonal face with wider-rooted and perhaps higher nose. They differ significantly from the males only in narrower skull base. But this typifies a more linear tendency of vault and central face which maintains L. H. III tendencies and fits the relative lack of Alpine females. In contrast with the Middle Bronze Age female sample which supports the male evidence for an invasion, the Early Iron Age females change far too little from the Mycenaean sample (though in the Dinaric-Alpine direction of the males) to suggest any effect at all from tribal movements linked with the Dorian intrusion.

The average Classical female may have a more dolichocrane and more angular vault joined to relatively bigger, more rectangular, and less

TABLE 3

Mean characters of seven successive chronological series: ancient Greek females

CHARACTER	NEOLITHIC & E. H. a. 3000-2000 B. C.		M. H. TO L. H. II ca. 2000-1400		L. H. III (MYCENAEAN) a. 1400-1150		EARLY IRON AGE a. 1150-650		CLASSIC 650-150 B. C.		ROMAN 150 B. C.-450 A. D.		BYZANTINE a. 450-1300 A. D.	
	Mean	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Horiz. circumf.	498.1	11	*509.0*	7	**497.7*	21	501.2	10	497.2	17	501.1	15	497.5	6
Cranial length	174.3	14	**181.1*	12	*174.7*	26	176.9	15	177.3	27	176.2	16	177.3	7
Cranial breadth	**139.1‡*	14	*135.2*	12	135.9	26	136.8	15	135.3	27	137.8	16	134.3	7
Bas.-brg. ht.	131.2	6	133.2	5	128.1	17	128.4	13	128.9	17	128.3	14	*132.1*	7
Auricular ht.	112.2	9	114.0	10	112.8	25	112.2	14	112.3	24	112.9	15	*115.8‡*	9
Minimum frontal	93.7	12	91.5	6	92.3	23	92.0	13	93.1	16	93.7	16	95.4	5
Basion-nasion	96.2	5	102.0‡	4	**94.0*	17	95.4	10	95.7	14	96.3	14	*99.3‡*	6
Facial angle	90.7	4	89.7	3	82.6‡	11	*87.3*	12	85.0	10	87.4	11	87.2	4
Bizygomatic br.	117.3	4	119.5	2	119.7	14	*124.7*	7	124.3	14	124.1	12	121.4	5
Bigonial br.	91.7	5	91.3	5	90.5	2	91.3	12	94.3	8	95.0	8	94.5	2
Bicondylar br.	*106.5*	4	*116.0*	4	118.5	2	116.3‡	12	120.5	7	114.9	5	115.5	2
Upper face ht.	67.0	2	62.5	4	64.3	13	65.2	13	66.3	12	66.3	12	64.4	5
Nose height	47.5	4	45.8	5	47.2	13	48.1	13	*50.5*	12	49.1	12	47.7‡	6
Nose breadth	22.2	4	23.2	6	23.0	12	22.5	11	**24.8‡*	12	**23.6*	11	23.6	5
Upper nasalia br.	12.9	10	*10.9*	7	11.3	20	*13.3*	8	13.4	15	*11.2*	11	12.4	5
Chin. ht.	30.0	8	*27.5*	6	29.0	2	29.7	13	30.0	11	29.7‡	7	*26.5*	4

TABLE 3 *(continued)*

Mean characters of seven successive chronological series: ancient Greek females

TABLE 3 *(continued)*

Mean characters of seven successive chronological series: ancient Greek females

CHARACTER	NEOLITHIC & E. H. a. 3000-2000 B. C.		M. H. TO L. H. II ca. 2000-1400		L. H. III (MYCENAEAN) a. 1400-1150		EARLY IRON AGE a. 1150-650		CLASSIC 650-150 B. C.		ROMAN 150 B. C.-450 A. D.		BYZANTINE a. 450-1300 A. D.	
	Mean	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*
Cranial index	*79.9♯	14	*74.8♯	12	78.3	26	77.6	14	76.6	26	78.4	16	75.8	6
Length-aur. ht.	63.8	10	62.8	10	64.0	24	63.7	13	63.7	23	64.9	15	65.8	7
Breadth-aur. ht.	80.6♯	10	*83.5	10	82.4	24	81.9	13	83.0	23	82.1	15	86.5	7
Fronto-parietal	*64.7♯	12	68.3	6	68.1	23	67.6	13	68.7	16	68.1	16	71.2	4
Cranio-facial	84.3	4	88.0	2	91.3	14	89.6	10	*93.0♯	13	89.3♯	12	90.9	5
Upper facial	53.8	3	54.0	2	53.1	11	53.4	10	53.8	10	53.5	12	53.0	4
Nasal index	47.0	4	50.2	6	49.3	12	46.8	11	49.8	11	47.8	12	49.5	5
Left orbital	84.8	3	87.5	3	89.2	10	87.0	10	88.6	12	85.3	12	83.2	3
Stature in cm.	146.3	4	153.4	8	147.1	1	153.8	10	154.2	10	157.4	5	151.0	2
Mean deviations:														
38 measurements	(1.58)		3.28		3.12		1.56		1.31		1.24		1.76	
15 indices	(2.18)		2.85		1.95		1.94		1.65		1.57		2.22	
Mean Sigma Ratio					97.3	21	91.4	15	96.5	20	92.3	16		
No. characters					13		3		14		8			
Age at death	29.6	17	30.1	13	28.0	27	31.9	16	33.7	27	30.9	14	31.0	9

Note: Values deviating from the preceding period group by from 2.5 to 3.0 times the p.e. are starred, by 3.0 to 4.0 italicized. Values deviating significantly from the corresponding male period group are marked ♯. Mean deviations are based on the total number of characters studied. Those listed for the earliest period group are deviations from the total series of females. The Submycenaean Cephallenian series is omitted.

orthognathous face, but with significantly bigger nose. This all parallels the males, except that the female nose size increase outstrips the males enough for significant excess in nose breadth. Yet change in female type frequencies is almost lacking. This parallels male reduction in degree of metric change, but may also arise from typing difficulty with the homogeneous Classical sample.

Roman period females average only slightly broader-vaulted and more byrsoid than the Classical series, with more sloping and pinched forehead. The face is significantly narrower relative to broader vault, with narrower nose suiting significantly narrower nasalia, and less alveolar projection, with a tendency toward an overbite. The slightness of this change in a dinaroid direction parallels the type frequency shift in which Basic White increase balances Dinaric-Mediterranean dominance. Except for significantly lower cranio-facial index and deeper chin, explicable as dinaroid modification of Classical or earlier facial traits, the female sample fits the males. Dinaric-Mediterranean excess in both sexes may have meaning as an indicator of immigration or as a product of Iranian-Alpine combination. In either case it anticipates modern Greeks more than does the Byzantine sample.

Females of Byzantine times are inadequately represented by a sample which combines a rhomboid, low mesocrane, significantly longer-based and higher vault marked by steeper frontal, with smaller face showing a significantly shallower chin and more expanded nasalia. This suits Mediterranean dominance, but diverges from the males in length, height, and shortness of nose, almost certainly because of sampling.

TYPE CONCLUSIONS

Here the outstanding conclusion is the chronological stability of females[16]. The females change less and more slowly than males and strengthen the evidence for genetic continuity in Greece in spite of many invasions. Female stability may determine their relatively low Sigma Ratios (Howells, 1941, pp. 144-147) and period group Coefficients of Variation (Vs of measurements with N over 14) at 91 per cent of male

[16] Mean metric deviations are higher for females because of small series' random variations: third millennium, M. B., Byzantine samples.

values, but not the female indicial sigmas at 109 per cent of corresponding male values[17].

Stability in morphology and trait combinations is expected because of female maturity at a slightly younger growth phase than in males (Ellis, 1904, p. 65), and is seen in relatively greater overlaps between types than occur among males. Segregation in morphology is less clear, therefore, among the females except for contrast between Alpinoids, Dinaroids, and the three linear types as a unit: distinction of types A, B, and D from each other and of type E from type C would be impossible if typing had been done on the females only, without seeing the males, instead of simultaneously. Yet the same single phenotypic traits occur in both sexes.

All the type frequency and period group discrepancies between the sexes spring from stability of the females or else from inadequate samples. Thus the combination of female with male type frequencies[18] gives a mean period to period frequency change only 83 per cent that of the males and 85 per cent that of the females alone, stressing racial continuity again, diminishing irrelevant period to period fluctuations but making relevant ones clearer (*cf.* Angel, 1944, pp. 359, 368).

Except for the inadequate third millennium and Byzantine samples the females follow the general male trend from a generalized Mediterranean toward a subtly dinaricized Alpine norm[19]. They also confirm male jowl broadening and nose size increase, suiting the hypothesis that these involve genetic recombination of tendencies from all types except gracile Mediterranean and Mixed Alpine. Females are too scanty to say if they would support the male reduction of variability during the

[17] But vault indices are the only ones available (N over 14) and the total series of females' sigmas for indices plus angles average 92.5 per cent of male values, according to variability constants unpublished because of lack of tabular space. Medieval Norwegians from Oslo (Schreiner, 1939, pp. 126-128) show female indicial plus angular sigmas 95.5 per cent of male values, and metric Vs 96 per cent of male Vs. This finding, normal for cranial series, contradicts Ellis' (1904, pp. 476-497) contrast of greater male variability in everything *except* size (as a result of birth selection), except for possible incorrect sexing or probable greater male chronological change. In any case reduction of range of female variation is not the same thing as biological stability, though the two may be related.

[18] Combine Table 2 with Angel, 1944, Table 6.

[19] Clearer in face broadening and nose size increase than in vault broadening: change is much more obscure.

Bronze Age, with subsequent fluctuations and rise, though subjectively their heterogeneity seems to parallel that of the males.

At least between Late Bronze and Roman times the females reflect the male pattern of change, but do so feebly, giving rise to the stability hypothesis just stressed. Here the females seem to continue the general physical pattern (often the male characteristics) of the preceding period: a female lag in speed of change. This could result from more male than female invaders buried in the various cemeteries excavated as much as from actual female genetic stability. Evidence is inadequate to test this. But series from various regions involved in settlement of migrants fit such a phenomenon[20].

As among the males, increase in female stature[21] occurs from prehistoric to historic times linked chiefly with diet and hygiene improvement and not forecast by type frequencies. No preceptible change in female skull capacity accompanies this, but an increase occurs in skull base length.

Although types clarify racial dynamics among females as among males, lack of type flexibility is equally clear, for instance, in nose and gonial breadth changes unpredicted by type changes. But the females stress another limitation still more. The multiple effects of single genes, linkages, and unknown selective factors which maintain the variety here schematized in types allow actual exchange between types of various trait associations when the two sexes are compared. Though several of these may be sampling errors, others may be real: partial exchange among females of muscular lower facial patterns of Basic White or Nordic-Iranian male association with linear ones of Mediterranean or Dinaric-Mediterranean association respectively; possible exchange of Alpine and hybrid Alpine face patterns, so that female Alpines are more linear-faced than the males[22] and Mixed Alpines lower-faced. Some morphological detail also appears crossed over. But apart from greater female stability the main sex difference in types is in crossed association

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[20] Bronze Age east Cypriotes and Medieval-Renaissance Hythe English with females more Mediterranean; Bajuvars and Anglo-Saxons with females very slightly more Alpinoid.

[21] Statistically significant in both sexes if period groups are combined: Prehistoric, Early Iron Age, and Historic.

[22] Similarly Hooton (1937, pp. 187-211) finds 11 per cent more Dinarics (defined largely by broad heads linked with narrow noses) among United States females than among males.

between linear and lateral tendencies in different parts of the face as compared to braincase.

Besides obvious secondary sex body build features, females tend to be slightly more endomorphic and definitely less mesomorphic than males (Sheldon, 1940, p. 127), expressing retention of infantile traits. Largely through endocrine action these features must indirectly result from doubling of similar genes on the X chromosome. Some of these genes may have different interacting effects with body build genes on autosomes in each sex. Thus sex linkage may determine different facial association of linearity and laterality in the two sexes[23]. This tentative hypothesis can be checked only by a careful inheritance study of body and cranial structure; it may be simply another expression of female stability.

But even if relative trait exchanges between types results from sex linkage, types have other inflexibilities. One example is the occurrence of low horizontal, almost elliptical orbits under beetling brows as a "Corded" (type D 2) trait in Bronze Age but not historic times (Angel, 1944, p. 349, footnote 14). Another example is the *rhomboides aegyptiacus* vault with inward taper of flat or inferiorly concave sidewalls in Early Bronze Age slightly dinaricized Mediterraneans. A third instance is the overwhelming dominance of linear "Megalithic" (type A 1) skull vaults in Cephallenian Basic Whites as compared to the Mycenaean males (Angel, 1943, p. 241) where the Basic Whites (mainly type A 3) are less linear with some Mixed Alpine similarities. Such morphological details are more or less lost in averaging the traits of each arbitrary type.

Hence we need further refinement of morphological description of population change beyond that available from the average individual and from types. Allowing for inadequate sampling, female stability and slight effects from what may be sex linkage, racial types are virtually identical in the two sexes and as applied to history clarify invasions, environmentally caused changes in body size, trait recombinations, female lag in speed of change, and perhaps greater social mobility of males. But types are not flexible or sensitive enough even if one multiplies the number of types used. With present data and ignorance, subjective description can fill the gaps. But not in the future.

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[23] The situation might parallel Brues' (1941) discovery of a sex-linked recessive light eye colour factor. Where many interacting genes are involved, sex linkage is difficult to uncover.

TRAIT COMBINATIONS

Perhaps fairly soon inheritance studies will identify morphological trait groups or tendencies which result from single gene or closely bound linkage group effects, at least with the definiteness with which we now know inheritance of pigmentation to result from multiple genetic factors relatively sensitive to selection. Until then it might be useful to identify and record those trait combinations which are subjectively apparent in restricted regions of head or body [24] and of which types are syntheses.

Two examples are listed in Tables 4 and 5. As expected, these trait groups are much more definitely associated with types than with period samples. But they do show in relatively balanced form such details as the normally Alpinoid broad-rooted interorbital and browridge form unexpressed by type frequencies in the Early Bronze Age; the peculiarly arched, "Mephistophelean," browridge-nose root formation (normally Nordic-Iranian) common in Classical-Roman times; or the normally Iranian-dinaroid jaw and occlusal plane tilt common in the Early Iron Age. The examples also show how each type changes slightly from period to period. And depending on the accuracy with which such details can be charted at various periods in regions in cultural contact with Greece, the trait combinations will give more precise information than now objectively available on origins of immigrants. Relative frequency of such details should give a much closer estimate of genetic similarity between ethnic groups than can unaided metric averages, which omit many important morphological details tedious to handle as single observations. Salient features, such as the "Iranian" nose, could be traced in space and history, with full account of recombinations changing them. And finally trait combinations may bridge the gap between type and individual total patterns of physical features, since similarity in trait combinations links differently typed members of "family" cemeteries in Geometric Athens, Submycenaean Cephallenia, and Roman Corinth[25], at times of racial heterogeneity.

Yet without knowledge of the genetic value of various traits and

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[24] *Cf.* Pearson and Woo (1935), p. 465, for the speculation that the uncorrelated shape characters of separate cranial bones may be of special value for racial (i. e. genetic) distinctions, since neither gross size nor contiguity correlates with bone variation.

[25] This partly answers the otherwise justified criticism that an isolated type is genetically meaningless because in a mixed population (without deliberate selection) no type would breed true (Washburn, 1944, p. 75).

without standardization of observations it is impossible to substitute trait combinations for types or for the average individual. Their most effective rôle might be as supplements to averages and as the units from which to build up types. Such types should be closer to genetic reality than types chosen either from arbitrary statistical subdivisions or by subjective matching, though both methods make unconscious use of trait combinations. Such types could also be redescribed to show both geographic and historic plasticity [26]. Trait combinations would give types more flexibility and add necessary detail to the realities which averages simplify. But until we can test observations genetically (*cf.* Washburn, 1945) and standardize them, the only scientific alternative is to publish properly oriented photographs of all material studied.

DISCUSSION

We can now sketch the relative worth of the average individual, types, and trait combinations as generalizations of individuals in ethnic groups for the five problems outlined in the introduction.

To the insistence of Karl Pearson and the Biometric School we owe the development of the present system of statistics for testing the reality of differences between samples of different populations and of associations within any population. Thus the average individual (with variability constants) is indispensable to any search for (1) origins, (2) chronological change, or (3) subgroup distinctiveness. And correlation coefficients and measures of variability are preliminaries to work on (4) associations between morphology and behaviour or on (5) individual diversity. But inevitably these workers have tended in the past to subordinate social and even genetic realities of cultures and individuals. They have treated human populations like animal breeds whose measurements were the only genetically important traits. Pearson is quoted (Morant, 1940, p. 77) as deprecating study of "parochial" groups since

[26] Only within a broad margin of error can "rugged Mediterranean" traits be identified morphologically in early urban southern Mesopotamians, Chalcolithic Palestinians and Sardinians, and British and Swedish Neolithic skulls, since the phenotypic (and genetic?) elements which these ethnic samples share are in each case a varyingly integral part of different local combinations. Yet it is far easier for the historian or other non-specialist to think of a single "type" common to these groups and differing slightly as it is combined with Iranian, Mediterranean, Alpine, Upper Palaeolithic, and Corded Nordic traits respectively in the different ethnic groups (*cf.* Coon, 1939) than to think in terms of gene or even trait frequencies.

TABLE 4

Trait group combinations for nose root plus browridge form: both sexes

PERIOD	BASIC WHITE	MEDITERRANEAN	NORDIC-IRANIAN	DINARIC-MEDIT'R'N	MIXED ALPINE	ALPINE	TOTAL a	b	c	d	e	N
Neolithic	c	c	a	c								
	2d			e	d	e	1		3	3	2	9
Early Bronze	a 3b		2a									
	3d 2e	2d 3e	2d	d	2e	d 3e	3	3		9	10	25
Middle Bronze	2c		3a b c	c	c	a						
	3d	2d	4d	d	d 3e	2d e	4	1	5	13	4	27
Late Bronze	8b 9c	5c	a b c	a	2c	2c						
	2d	7d 2e	d 2e	2d	3d e	5d 3e	2	9	19	20	8	58
Cephallenia Submycenaean	a 5b 3c	a 3c	2a 2c		c	b						
	d	4d			3d	d	4	6	9	9		28
Submycenaean	c	a	a c	b c		b						
		d	d	2d	d	2d e	2	2	3	7	1	15
Geometric	c	2c	a c		b	b 2c						
		3d	e d		2d	d	1	2	6	7	1	17
Classic	2b 6c	3a 3c	6a 3c	2a c	b	2b c						
	5d	7d	7d	2d	4d e	5d 2e	11	5	14	30	3	63

TABLE 4 *(continued)*

Trait group combinations for nose root plus browridge form: both sexes

PERIOD		BASIC WHITE	MEDITER-RANEAN	NORDIC IRANIAN	DINARIC-MEDIT'R'N	MIXED ALPINE	ALPINE	TOTAL a	b	c	d	e	N
Roman		2b 3c	a c	4a b	3a b 2c		c b c						
			2d		d	d e	2d e	8	5	8	6	2	29
Byzantine		2c	b 4c	b 2c			c 2b 2c						
			8d	d	2d		2d e		4	11	13	1	29
T	a 2		6	21	6		1	36					
O	b	20	1	4	2	2	8		37				
T	c	28	19	11	6		6 8			78			
A	d 14		38	16	12	16	21				117		
L	e	2	5	3	1	8	13					32	
N		66	69	55	27	32	51						300

Key: a: "Mephistophelean": divided browridges, with lateral segments swept back and strong median segments pointing into arched nose root.

b: "Lowering": heavy, horizontal, and often continuous browridges and glabella overhanging a deep nasion depression.

c: "Clearcut": strong browridges with lateral segments only slightly sloping, and nasalia sharply angled with nasal processes of maxillae.

d: "Intermediate": rounded browridges with lateral segments sloping.

e: "Infantile": relatively weak browridges, laterally spreading, with wide interorbital and wide poorly arched nose root, slight nasion depression.

TABLE 5

Trait group combinations for mandibular and alveolar form: both sexes

PERIOD	BASIC WHITE	MEDITER-RANEAN	NORDIC-IRANIAN	DINARIC-MEDIT'R'N	MIXED ALPINE	ALPINE	TOTAL a	b	c	d	e	f	N
Neolithic	a			b c		e	1	1	1		1		4
Early Bronze	c d	2a d	b c			b d	2	2	2	3			9
Middle Bronze	c 2e	a d	2a b 4c e	a 2c	b c 4d	3f	4	2	8	5	3	3	25
Late Bronze	f	2a 2d	a 2c	c		f	3		3	2		2	10
Cephallenia Submycenaean	2a f	a	c		c		3		2		1		6
Submycenaean	c	b	b d	2b 2c	d	4d f		4	4	6		1	15
Geometric	b	a b c d 2e	b c d	b c d	2d	2d 2c	1	4	5	7	2		19
Classic	c d	2a 2d e	a b 8c e	c 2d e	2d	3d e 2c f	3	1	12	10	4	1	31

TABLE 5 *(continued)*

Trait group combinations for mandibular and alveolar form: both sexes

PERIOD		BASIC WHITE	MEDITER-RANEAN	NORDIC IRANIAN	DINARIC-MEDIT'R'N	MIXED ALPINE	ALPINE	TOTAL a	b	c	d	e	f	N
Roman			2d	2c	d b 3c	e	2d c		1	6	5	1		13
Byzantine		d	2a 2b c 2d	a c e	c		2d 2c	3	2	5	5	1		16
TOTAL	a	3	11	5	1			20						
	b	1	4	5	5	1	1		17					
	c	4	2	21	12	2	7			48				
	d	3	11	2	4	9	14				43			
	e	2	3	3	1	1	2					12		
	f	2					6						8	
N		15	31	36	23	13	30							148

Key: a: "Linear": long, linear jaw, compressed angles, strong (and deep) chin.
b: "Tilted": long body with short ramus, sloping teeth row, giving effect of weak chin and slight prognathism.
c: "Angular": rugged and angular jaw, with bilateral-triangular chin, and strong but not square angles.
d: "Intermediate": somewhat wide and rounded jaw with shallow and clearly projecting chin.
e: "Infantile": more prognathous and open-angled version of "d" with weak chin.
f: "Squat": short ramus, relatively square angles, short and shallow body, and chin strong.

these do not each represent the whole ethnic group which he maintains is the only real unit, being ultimately of common descent: virtually a "race." Morant's own discussion (1940) of factors acting in a population, definition of difficulties, rejection of unassisted χ^2 for heterogeneity, and decision that empirical tests are the only answer (*cf.* Washburn, 1944, p. 74) is extremely constructive. Yet even here Morant uses "race" as equivalent with "an intermarrying population" (ethnic group), and considers metric and indicial averages and correlations the chief material to be analyzed.

(1) Population origins are simplified greatly by use of the average individual (or Coefficient of Racial Likeness) plus close consideration of geography and historical data. But averages group British Neolithic and German Reihengräber skulls (Morant, 1928, group D) which Coon (1939) by historical analysis shows to have completely separate origins, though with probable Upper Palaeolithic and Near Eastern common ancestries in the remote past. More sensitive analysis, as by trait combinations (or perhaps types) is indispensable in working out pre-Greek and Greek origins, as in part of the Early Bronze material.

(2) Chronological change can be tested only through use of the average individual, as seen in outline of the general evidence for racial continuity in Greece. But types give a much more vivid picture. And trait combinations allow a more flexible appreciation of the dynamics of change brought into focus with migrations, social selection, and environmental factors of history.

(3) Physical distinctiveness of subgroups, as in contrast between Submycenaean Cephallenians and Isthmian Greeks of L. H. III or Early Iron Age dates (Angel, 1943) must also be tested with statistics based on the average. But groups diverse in one tendency (e. g., linearity) which affects several measurements and many indices, may be united by similarities clear only in trait combinations, types, or even purely subjective description.

(4) Since association between physique and behaviour may seem to connect socially approved or disapproved behaviour with heredity, this problem has led honest scientists toward the Charybdis of assuming that correlation shows cause, or the Scylla of denying any connection between physique and mind because of the real danger of such bogeys as "Nordic superiority" (*cf.* Ashley Montagu, 1942, Ch. 10).

Twin studies show that patterns of thinking and action are set in motion by genetic forces (Burks, 1942), but that extremely slight or tran-

sient environmental factors may reverse or invert a large part of the whole dynamic pattern of development. Even with twins it is far harder to compare psychological inheritances than to compare body builds of people wearing fur coats. Correlations of intelligence with body build or with race have always been shown to result from cultural factors (Benedict and Weltfish, 1943, p. 18). And Klineberg, Asch, and Block (1934) find no statistically significant differences in mental tests between two extreme body build groups in culturally "homogeneous" (?) samples. Thus statistics show no connection whatever between mental and physical traits if cultural factors are eliminated.

But Jost and Sontag (1944) show a genetic factor in autonomic function, paralleling "physical vitality" trait similarity in twins[27]. And Sheldon (1942) shows correlations of about .80 between physical types and temperamental tendencies. Part of the strength of these correlations must result from differences in ethnic background and from the individual's conditioning by his own physique. But because Sheldon's temperamental traits are largely expressions of degree and kind of physical vitality they tend to establish the reality of genetic factors in psychosomatic unity at action level, without denying lack of association at mental level. On the border between these Klineberg (1931) found the only test to show any hint of association with rather inclusive types was of Rorschach type. Burks (1942) found Rorschach tests promising as indicators of genetic background of behaviour. This suggests that there may be deeply hidden genetic factors under interwoven cultural determinants behind Hooton's (1937) demonstration of social and ethnic peculiarities linked with physical types. Estimated somatotypes[28] of the ancient Greek types suggest they may have shown average temperament differences. But there is no evidence of consistent association

[27] Burks (1942) naturally could not rule out intrauterine influences.

[28] Using relative hip and clavicle breadths, femoral robusticity, long bone smoothness, ruggedness, or gracility, tarsal size, lumbar vertebrae size and curvature, etc., in addition to skull morphology. Combining both sexes, 4 Basic Whites average 2.2—3.8—4.2; 6 Mediterraneans average 2.6—3.0—4.2; 10 Nordic-Iranians average 3.1—4.3—3.3; 13 Dinaric-Mediterraneans average 3.3—3.5—4.0; 4 Mixed Alpines average 4.3—3.5—2.4; and 12 Alpines average 4.1—4.3—2.6. Despite the subjectivity of such estimates and the vast overweighting of the head region, there is enough correlation between different body regions (Sheldon, 1940, pp. 68-72) so that the tendency of the estimates must be correct: endomorphy rises and ectomorphy falls steadily from Mediterraneans to Alpinoids, and Alpines, Nordic-Iranians, and Basic Whites are rugged.

of any type with a particular phase of historic achievement or with social strata. And any physique-temperament association depending on gene linkage alone (as opposed to single gene or multiple factor action via physiological control) will be continually changing and never a definite part of one type even through social selection.

Three conclusions result: use of types and correlations show (a) no linkage between mentality and physique, (b) definite association between temperament and physique, whose expression is determined entirely by (c) social factors of all sorts, including cultural attitudes toward peculiarities of physical appearance and performance, factors far too strong to allow qualitative association of type with cultural change.

(5) But Hooton has shown (1937, pp. 187-211) that physical types do have distinct if transient behaviour patterns in a highly heterogeneous population including many recent immigrants diverse in ethnic and genetic background. Ancient Greeks as a whole were heterogeneous, particularly in Middle Helladic, Roman, Byzantine, and probably Submycenaean-Protogeometric periods of ethnic change and historic turmoil (Angel, 1944, p. 371). Divergence of females in Middle Bronze and late historic periods stresses heterogeneity. And it is likely that for a generation or more after intrusion of any large group of immigrants attributions of characteristic behaviour to new physical types would persist, different in each historical instance, and increasing cultural diversity of individuals. In addition to this and other social reactions to physical type, involving especially greater sex difference in type and sexual selection, all the genetic phenomena of mixture will be important. Hybrid vigour will play some part. And if the genetic background allows the assumption that diversity in vitality and temperament (as a quantitative thing) parallels physical heterogeneity, richness of new combinations and vitality offer a force to use the materials for cultural development which ethnic mixture provides.

Going on the fairly logical assumption that genetic mixture must parallel ethnic mixture to some extent, many historians and anthropologists have deduced that "race mixture" and variety are necessary for flowering of civilization (e. g., Hertz, 1925; Ashley Montagu, 1942). This general principle will need deeper analysis in which ethnic and genetic factors must be kept separate in order to see how they interact. For this purpose types express individual variety as opposed to uniformity vividly, since variability constants taken alone measure only the spread and deviations from the normal curve in single dimensions or pro-

portions without regard for correlations with morphology: the average variability of an artificially (Morant, 1940, pp. 85-91) or naturally (Wallis, 1938) mixed population need not be abnormally high. And the balance between types (together with degree of sex difference) among ancient Greeks is an excellent subjective check on actual variability parameters.

Discussion of human biological change in Greece shows the average individual most useful for chronological changes and subgroup comparison, trait combinations invaluable for origins, and types most useful for social biological problems where the whole individual *is* indivisible. Obviously all three approaches must interdigitate in many studies to achieve objectivity and prevent prejudiced oversimplification. Equally obvious are two weaknesses. Types may be miscalled races and be misused by racists just as disastrously as ethnic groups may be confused with races. And to check hypotheses used in this essay we need more animal experiments on heredity (*cf.* Washburn, 1945) and on its interaction with environmental forces molding physical and psychological growth. This applies specially to the relative value of various physical traits for assessing genetic similarity, and to aspects of the hypothesis of biological stability of females.

SUMMARY

(1) For many human biological problems race and ethnic group as expressed in the imaginary average individual are not adequate generalizations of human populations.

(2) The concept of racial type is tested on skeletal material with reference to five problems.

(3) Ancient Greek females show essentially the same six types as the males, and the same historically, genetically, and environmentally determined chronological changes.

(4) Female type and period series diverge from male series because of inadequate samples, greater female morphological stability, and trait shift possibly connected with sex linkage.

(5) Female stability shows in relative slowness to change, and further stresses racial continuity in Greece, with heterogeneity at certain periods.

(6) Types make vivid the biodynamics of population change, but are too inflexible and artificial in representing genetic reality.

(7) "Trait combinations" fill in some of the deficiencies of types and of the average individual, especially for the problem of origins.

(8) For certainty of chronological change in ethnic groups and for distinctiveness of social subgroups averages are indispensable and types and trait groups clarifying.

(9) For problems of psychosomatic association and social meaning of individual variety types are indispensable, checked by statistical parameters.

(10) Heterogeneity, as seen in the balance between contrasting types, is a possible source of energy for culture growth and is a major subject for research in social biology.

(11) Confusion of ethnic group, race, and type concepts is hard to avoid, and gives racial propagandists opportunity to distort truth.

(12) We need experimental testing of the type concept and which morphological or metric features can best measure genetic similarity.

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CHRONIC SICKNESS IN RELATION TO SURVIVORSHIP TWENTY YEARS LATER[1]

BY ANTONIO CIOCCO

INTRODUCTION

THIS is the first report of an investigation made in 1943 on more than 1800 white families who cooperated in a sickness survey conducted by the U. S. Public Health Service from 1921 to 1924 in Hagerstown, Md. In this paper data are presented on the mortality observed during the twenty year interval in persons with chronic ailments at the time of the original survey.

The investigation was undertaken to obtain information on the relationship between health status, familial and socio-economic characteristics observed and recorded in 1921-24 and the subsequent record of sickness and mortality. The resurvey thus provides a series of repeated observations on a sample of the general population, and an opportunity to evaluate, within the limits of the data, the influence of conditions noted in the first survey on the development of the more common fatal diseases.

Among the items that will be examined first are the kinds and amount of sickness prevalent at the time (1921-24). Surveys conducted in Hagerstown and elsewhere have indicated the magnitude of the sickness problem in the population, the large number of persons affected and the resulting disability. It is clear from these reports that there is great disparity between volume of sickness and the number of deaths at any given time. The bulk of the sickness found in the general population consists of the acute and so-called minor ailments and is not reflected in the current mortality. However, it is not known whether frequent attacks of minor sicknesses, or their persistence over a long period of time eventually will influence longevity by producing injuries to some vital organ-system and reducing resistance to the development of other and more fatal diseases. The data obtained from the surveys made twenty years apart have been analyzed for the purpose of throwing some light on this

[1] From the Division of Public Health Methods, U. S. Public Health Service.

question; the results of the analysis with reference to the relationship of chronic sickness to mortality constitute the basis of this report.

MATERIAL AND METHOD

The procedures employed in collecting the data in 1921-24 were described in detail by Sydenstricker.[2] The survey was initiated in November, 1921 with a house-to-house visit in selected sections of Hagerstown, in the course of which information regarding social and health status of the families, and the sanitary conditions of the household were obtained. Following this visit, and at intervals of 6 to 8 weeks until March 31, 1924, home canvasses were made to inquire about sickness which had occurred between visits. It is important to note that for all cases attended by physicians, the statements on the nature or cause of illness were submitted to the physicians concerned for review and correction.

The records of that survey have served as a starting point for the investigation conducted between January 1 and December 31, 1943. The first step in this investigation was to locate the 1800-odd families, and for the purpose the following sources were utilized:

1. Family records of the Hagerstown office of the U. S. Public Health Service.
2. Birth and death records of the Washington County Health Department.
3. City and telephone directories.
4. Records of the County Tax Assessor's Office.

When the residence of one or more members of a family was located within the city, home visits were made to elicit information about present health, marriage, and reproductive history of all the living members of the family, and cause and date of death of those who had died. For persons who had died in the county or had been interred there, the information obtained was verified by checking death and burial certificates. It should be noted that the 1921-24 survey was concerned with households and included data on roomers and boarders. In the 1943 field work no attempt was made to trace such individuals.

There were records of 1822 families available for this investigation. In 1943, contact was made with 1628 or 89 per cent of the original group of families. By contact is meant that at least one member of the family

[2] Sydenstricker, E. A study of illness in a general population group. Hagerstown morbidity studies, No. 1: The method of study and general results. *Pub. Health Rep.*, vol. 41. pp. 2069-2088, 1926.

was interviewed, or that death certificates were found for all members of the family. The high proportion of families found to be still in Hagerstown is an index of the stability of the population of that community. It is planned to describe the demographic aspect of the findings in a separate publication, but it may be of interest to mention here that more than 25 per cent of the families were located at the address given in the 1921-24 survey.

The 1628 families that were located in 1943 contained originally 7239 individuals; but of these, 124 had died before the end of the first survey in 1924, and the whereabouts of 572 was unknown to the interviewed members of the family in 1943. There were 751 individuals in the 194 untraced families. In sum, in 1943, information about present health status was obtained on 6543 or 83 per cent of the 7866 persons alive at the end of the 1921-24 survey.

The untraced families were on the average slightly smaller than the traced, having 3.9 persons per family as compared with 4.4; and younger with an average age of 24.9 years as against 28.4 years. In the untraced families 48 per cent of the individuals were males while in the traced families the percentage was 49. There was no appreciable difference in the prevalence rate of recorded sicknesses. Among the untraced families, 19 per cent of the individuals had one or more chronic conditions as compared with 20 per cent of the individuals in the traced families.

The two groups of families were very unlike with regard to length of period under observation during the first survey. Following the classification employed by Sydenstricker the families may be grouped into (a) those in which no member was under observation for at least 26 months, and (b) those in which one or more members were observed for 26 months or more. In the untraced families only 56 per cent of the individuals belonged to families in which one or more members participated in the first survey 26 months or longer, while this is found in 82 per cent of the individuals of the traced families. A substantial number of the untraced families had apparently already moved from Hagerstown before 1924 when the first survey ended.

From these comparisons it may be concluded that the families located in 1943 are not entirely representative of the group originally surveyed. On the average, they were more stable and older. However, as has just been pointed out, the prevalence of chronic diseases was about the same in the untraced as in the traced families.

CHRONIC DISEASE RECORD

The analysis discussed in this paper is limited to a comparison of the mortality of persons with and without a history of some chronic sickness in 1921-24. It must be kept in mind, as Sydenstricker wrote, "that only those chronic conditions were revealed which manifested themselves in illness or definitely morbid effects as a result of the disease or condition during the period of observation. . . . . Latent or incipient diseases and conditions that did *not* manifest themselves in morbid effects obviously do not appear . . . . . ." Illness, as defined in the study, included non-disabling as well as disabling sicknesses, and was classified as chronic on the basis of the nature of the disease.

In view of these considerations, it was felt that the comparison between individuals who did and did not have a chronic condition would rest on sounder bases if the analysis were limited to individuals whose families had been under observation 26 months or more. In the original 1822 families such individuals numbered 6220, and of them information was obtained in 1943 on 5375 or 86 per cent. Of the 5375, 1147 or 21.3 per cent had had attacks of one or more chronic conditions between 1921 and 1924.

The frequency of the various chronic conditions reported by the 1147 individuals is illustrated in Table 1. This table shows that the conditions reported most frequently were neuritis and rheumatism. The least frequently reported were such diseases as cancer and tuberculosis. It should be pointed out that the frequency shown in Table 1 does not indicate prevalence of the conditions in the total 1921-24 sample; diseases such as cancer, tuberculosis and heart diseases are underrepresented because cases have been excluded that did not survive to the end of the survey in 1924.

As is well known, the reported prevalence of chronic disease is higher among the females than the males. In the sample of 5375 persons where 51 per cent were females, 29 per cent of the females had one or more chronic diseases as compared with 14 per cent of the males. Thus, among the persons with chronic ailments 68 per cent were females and 32 per cent males.

The persons with chronic ailments as a group were older than those without. A comparison of the age composition of the two groups is presented in Table 2. It is seen from Table 2 that only 38 per cent of the chronic disease group was below 30 years of age as compared with

TABLE 1

Frequency of certain chronic conditions recorded in 1921-24 in a sample of men and women resurveyed in 1943

DISEASES OR ORGAN SYSTEMS INVOLVED	INT. LIST CAUSES DEATH 1920	NUMBER OF PERSONS REPORTING SPECIFIED CONDITIONS		
		Males	Females	Both sexes
Neuritis, sciatica, etc.	81, 82, 84	45	212	257
Rheumatism	51-52	58	113	171
Upper respiratory	86, 97, 109	78	92	170
Stomach and intestines	111-119	45	89	134
Heart	87-90	30	70	100
Kidneys	128-131	26	59	85
Bones	155-158	24	59	83
Female genital organs	137-142	—	68	68
Liver and other digestive	120-127	12	51	63
Lower respiratory	99, 102, 105, 107	16	42	58
Vascular	74, 91-96	13	25	38
Bladder and other genito-urinary	132-135	17	21	38
Tuberculosis	31-37	11	19	30
Cancer	43-49, 65	2	6	8
All other	—	55	183	238

62 per cent of the non-chronic group. At the other end of the age scale, one finds that 28 per cent of the chronic disease group was 50 years or older in contrast with 12 per cent of the persons with no record of a chronic ailment.

MORTALITY AFTER TWENTY YEARS

After nearly 20 years one finds that 20.1 per cent of the 5375 persons in the surveyed families are dead.[3] This is equivalent to an average annual mortality of about 10 per thousand. As expected, the mortality

[3] The deaths took place between April 1, 1924 and December 31, 1943.

TABLE 2

Age distribution and chronic disease record in 1923

AGE (yrs.) 1923	CHRONIC AILMENT		NO CHRONIC AILMENT	
	Number	Per cent	Number	Per cent
Under 5	38	3.4	445	10.7
5 - 19	276	24.5	1 499	34.9
20 - 29	115	10.2	662	16.0
30 - 39	175	15.6	604	14.6
40 - 49	203	18.0	477	11.5
50 - 59	139	12.3	284	6.8
60 - 69	103	9.2	159	3.8
70 and over	77	6.8	70	1.7
Total	1 126	100.0	4 150	100.0
Age unspecified	21		78	
Grand total	1 147		4 228	

among males was higher than that among females, the percentages being 21.3 and 19.0, respectively. The higher mortality of the males is evident at all ages as a comparison between Figs. 1a and 1b indicates.

The mortality of persons with some chronic ailments during 1921-24 was 33.0 per cent, almost double the percentage of deaths among the persons who reported no chronic ailment during that period. Of the latter only 16.6 per cent died during the last twenty years. As Figs. 1a and 1b reveal, the lower survivorship of the latter is limited to the age span between 15 and 50 years.[4]

For persons under 15 years of age in 1923, the mortality during the period 1925-43 was practically the same whether or not they complained of some chronic ailment at the time of the original survey. The sicknesses of which these children complained did not apparently affect their survivorship in the subsequent twenty years.

In the case of persons who were 50 years of age or over in 1923, and who survived to the end of the first survey in 1924, it apparently did not matter either whether they had or had not some chronic ailment, the sur-

[4] Age calculated as of February 15, 1923 for persons 5 years of age and over, as of March 31, 1924 for persons under 5 years.

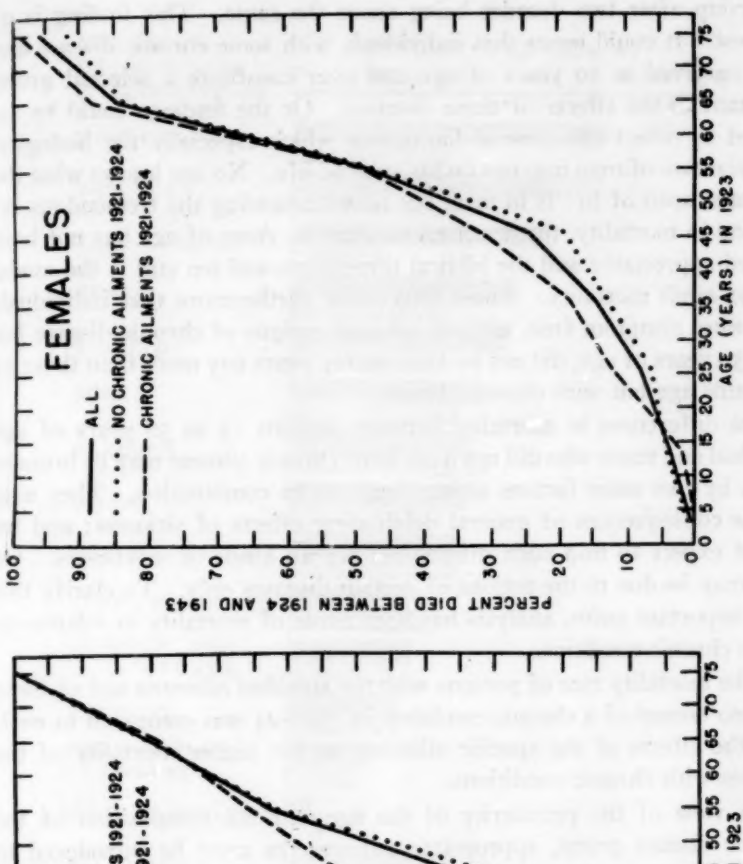

FIG. 1A-1B. MORTALITY BETWEEN 1924 AND 1943 IN RELATION TO AGE IN 1923

vivorship after two decades being about the same. This finding is of interest. It could mean that individuals with some chronic disease and who survived to 50 years of age and over constitute a selected group resistant to the effects of these diseases. Or the findings could be assumed to reflect the general limitations which especially the biological organization of man imposes on his span of life. No one knows what the potential span of life is in man, but notwithstanding the tremendous reduction in mortality, the death curve after 50 years of age has not been altered appreciably and the biblical three-score-and-ten still is the modal age of adult mortality. These data show furthermore that individuals who were symptom free, without subjective signs of chronic disease but over 50 years of age, did not survive twenty years any more than those of the same age but with chronic illness.

The differences in mortality between persons 15 to 50 years of age who had and those who did not have some chronic ailment may be brought about by two main factors acting singly or in combination. They may be the consequences of general debilitating effects of sickness; and we would expect to find such differences for all kinds of sicknesses. Or they may be due to the actions of certain diseases only. To clarify this very important point, analysis has been made of mortality in relation to stated chronic conditions.

The mortality rate of persons with the specified ailments and of those with no record of a chronic condition in 1921-24 was compared to evaluate the effects of the specific ailments on the higher mortality of the persons with chronic conditions.

In view of the peculiarity of the age and sex composition of the chronic disease group, appropriate adjustments must be introduced to make such comparisons valid. The adjustments have been carried out by applying the age-sex specific mortality rates observed in the non-chronic disease group to the age and sex distribution of the individuals with the specified chronic ailments. The results of these calculations furnish what is here called the expected mortality rate. These are shown in Fig. 2 together with the actual mortality rates for the persons with the designated chronic ailments.

It will be seen from Fig. 2 that there is considerable variation in the mortality which occurred among the individuals with the different types of chronic illnesses reported. About 75 per cent of the individuals with cancer and vascular diseases in 1921-24 died in the twenty year interval, while only about 5 per cent of the individuals with upper respiratory con-

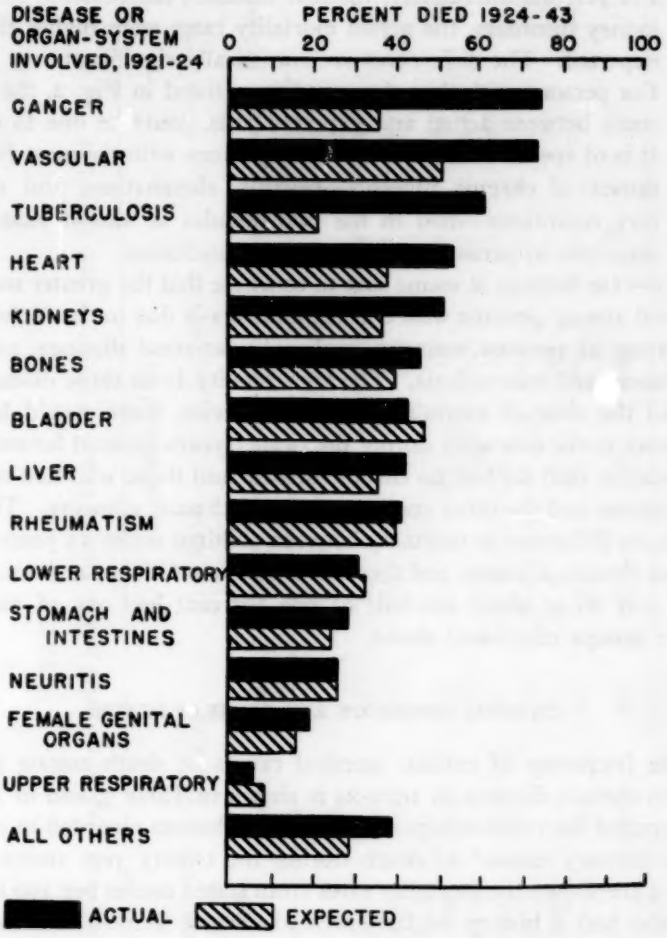

FIG. 2. MORTALITY FROM ALL CAUSES BETWEEN 1924 AND 1943 IN PERSONS WITH SPECIFIED CHRONIC AILMENTS RECORDED IN 1921-24

ditions at the time did not survive the two decades. A large part of this variation is, of course, due to the age of the individuals having the different types of chronic ailments. This is indicated also by the variation observed in the expected mortality rates according to chronic ailment.

When the actual and expected rates are compared for each chronic disease group it is seen:

1. For persons with cancer, vascular diseases, tuberculosis, heart and kidney disorders, the actual mortality rates were higher than the expected. The differences are statistically significant.
2. For persons with the other conditions listed in Fig. 2, the differences between actual and expected rates could be due to chance. It is of special interest to note that persons with the most frequent causes of chronic illnesses—neuritis, rheumatism, and respiratory conditions—died in the two decades at almost exactly the same rate as persons without chronic conditions.

From the findings it seems safe to conclude that the greater mortality observed among persons with chronic ailments is due to the inclusion in this group of persons with the cardiovascular-renal diseases, and also with cancer and tuberculosis. The high fatality from these diseases has affected the over-all mortality rate. Otherwise, there would be little difference in the mortality during the twenty years covered between persons who in 1921-24 had no chronic disease and those who had neuritis, rheumatism, and the other common types of chronic ailments. There is, in fact, no difference in mortality between children under 15 years of age without chronic ailments and those with such conditions; and among the latter only 20 or about one-half of one per cent had any of the three disease groups mentioned above.

CHRONIC CONDITION AND CAUSE OF DEATH

The frequency of certain specified causes of death among persons with no chronic diseases in 1921-24 is shown in Table 3, and in Table 4 is illustrated the relationship of the chronic ailments recorded in 1921-24 to the primary causes[5] of death during the twenty year interval. In Table 4 are shown the mortality rates from stated causes per 100 individuals who had a history of the specified chronic ailment. Comparable rates (shown in italics) have been calculated for the individuals with no chronic disease history by applying the observed age-sex specific mortality in this group (summarized in Table 3) to the age and sex distribution of the individuals with chronic disease. The data of Table 4 show that during the period 1924-43:

1. About 63 per cent of the persons living to the end of the survey

[5] Primary cause assigned according to the Manual of Joint Causes of Death, prepared by the Department of Commerce, Bureau of the Census, and published by the Government Printing Office, 1925.

TABLE 3

Mortality in 1924-43 from specified causes in persons with no history of chronic ailment in 1921-24

DISEASES, PRIMARY CAUSE OF DEATH	INTERNATIONAL LIST NO., 1920	AGE IN YEARS (1923)							
		Under 19		20-39		40 - 59		60 and over	
		Males	Females	Males	Females	Males	Females	Males	Females
		Per cent died from specific cause							
Heart	87-90	.3	.3	2.3	2.1	10.8	7.9	24.7	17.0
Vascular	74, 91-96	—	—	1.4	.5	9.5	7.9	25.6	18.8
Respiratory	11, 86, 97, 99-107, 109	.3	.6	1.7	1.0	2.9	.6	4.2	8.9
Cancer	43-49, 65	.1	.1	1.2	1.7	2.7	5.3	2.6	9.8
Kidneys	128-131	.2	—	.5	.3	1.8	.6	2.6	2.7
Tuberculosis	31-37	.7	.6	.5	.5	1.4	.3	—	.9
Digestive	111-127	.2	—	.6	.3	2.0	—	3.4	3.6
All others		2.1	1.8	5.3	3.0	10.6	7.2	23.1	24.1
Number of persons		1 015	879	661	605	443	318	117	112

TABLE 4

Observed and expected (figures in italics) mortality (1924-43) from stated causes in persons with recorded chronic ailment in 1921-24*

DISEASES OR ORGAN SYSTEMS INVOLVED, 1921-24	DISEASES CONSIDERED PRIMARY CAUSES OF DEATH							
	Heart	Vascular	Respiratory	Cancer	Kidneys	Tuberculosis	Digestive	All others
	*Deaths per 100 persons with specified condition***							
Neuritis, etc.	6.0	4.0	3.6	2.0	0.8	0.8	0.8	8.8
	6.2	*5.8*	*1.7*	*3.3*	*0.7*	*0.5*	*0.7*	*7.2*
Rheumatism	11.8	6.5	3.0	4.7	3.6	0.0	1.2	10.7
	9.4	*9.3*	*2.8*	*4.0*	*1.2*	*0.6*	*1.3*	*10.5*
Upper respiratory	1.8	0.0	1.8	0.6	0.6	0.0	0.0	1.2
	1.9	*1.5*	*0.7*	*0.8*	*0.3*	*0.6*	*0.3*	*3.3*
Stomach and intestines	12.2	3.8	2.3	0.8	1.5	0.0	0.8	6.1
	5.8	*5.2*	*1.8*	*2.7*	*0.8*	*0.6*	*0.8*	*6.9*
Heart	22.7	6.2	6.2	5.2	6.2	1.0	2.1	4.1
	8.8	*8.7*	*2.6*	*3.9*	*1.1*	*0.6*	*1.2*	*10.1*
Kidneys	15.3	8.2	2.4	3.5	11.8	1.2	2.4	7.1
	8.0	*7.9*	*2.4*	*3.3*	*1.0*	*0.6*	*1.1*	*9.3*
Bones	14.6	9.8	4.9	3.7	0.0	0.0	2.4	11.0
	8.8	*8.6*	*2.6*	*4.0*	*1.1*	*0.6*	*1.2*	*10.1*
Female genital organs	3.0	3.0	3.0	1.5	0.0	1.5	0.0	7.5
	3.9	*3.0*	*1.2*	*2.7*	*0.4*	*0.5*	*0.3*	*4.8*
Liver and other digestive	13.6	5.0	8.5	1.7	1.7	0.0	0.0	11.9
	7.4	*7.1*	*2.2*	*3.9*	*0.9*	*0.6*	*0.9*	*8.6*

TABLE 4

Observed and expected (figures in italics) mortality (1924-43) from stated causes in persons with recorded chronic ailment in 1921-24* (continued)

DISEASES OR ORGAN SYSTEMS INVOLVED, 1921-24	DISEASES CONSIDERED PRIMARY CAUSES OF DEATH							
	Heart	Vascular	Respiratory	Cancer	Kidneys	Tuberculosis	Digestive	All others
	*Deaths per 100 persons with specified condition***							
Lower respiratory	10.3	0.0	8.6	0.0	1.7	1.7	1.7	6.9
	7.2	*7.0*	*2.6*	*3.5*	*0.9*	*0.6*	*1.0*	*8.7*
Vascular	23.7	34.2	7.9	0.0	5.3	0.0	0.0	2.6
	11.4	*11.5*	*3.4*	*4.4*	*1.4*	*0.5*	*1.7*	*12.9*
Bladder and other genito-urinary	11.4	2.9	0.0	2.9	0.0	0.0	5.7	20.0
	10.6	*10.3*	*2.7*	*3.6*	*1.3*	*0.5*	*1.5*	*11.4*
Tuberculosis	3.6	0.0	7.1	0.0	0.0	42.9	0.0	7.1
	5.0	*4.0*	*1.4*	*2.0*	*0.6*	*0.5*	*0.6*	*5.8*
Cancer	0.0	0.0	0.0	62.5	0.0	0.0	0.0	12.5
	8.8	*8.5*	*2.3*	*4.0*	*1.0*	*0.5*	*1.0*	*9.6*
All others	6.8	6.8	2.1	3.4	1.3	0.4	0.4	17.1
	6.9	*6.5*	*2.0*	*3.4*	*0.9*	*0.5*	*0.8*	*8.0*

* Expected based on mortality in the group with no chronic diseases adjusted to age and sex composition of persons with specified chronic disease.

** Number of persons with each condition shown in Table 1.

and with a record of cancer died from cancer during the period 1924-43. The calculated rate for persons without chronic diseases is only 4 per cent. The difference is statistically significant even though based on a very small sample.

2. Vascular diseases were the most frequent causes of death in the group with these diseases in 1921-24. They occurred in 34 per cent of the individuals. Less than 12 per cent would have been expected. There is also a higher than expected mortality from heart, kidney and respiratory diseases in the vascular diseases group but in view of the size of the sample the differences between actual and expected could have been due to chance.
3. Forty-three per cent of the persons with tuberculosis in 1921-24 died of that disease. The adjusted mortality among the persons with no chronic disease is half of one per cent. The difference between the two rates is statistically significant. It will also be observed that in this group there is higher than expected mortality from respiratory diseases.
4. Among the persons with a history of heart disease, 23 per cent died from that same cause. This is significantly greater than the adjusted rate of 9 per cent for persons without chronic diseases. There is also a higher incidence of death from kidney and respiratory diseases in this group but the differences between actual and expected rates again may be due to chance.
5. Over 15 per cent of the persons with kidney diseases died from heart disease and almost 12 per cent from kidney diseases. However, the expectancy for heart disease is high, 8 per cent, while that for kidney diseases is only 1 per cent. Therefore, it is only with reference to the latter disease that one finds a significantly higher incidence of deaths in this group.
6. For the remaining conditions, the actual mortality rates for the various causes are not markedly different from the expectations based on the rates observed in persons without chronic disease. One does note a much higher than expected mortality from heart disease among the individuals with stomach and liver ailments, and disorders involving the bones; a greater mortality from respiratory diseases among persons with liver and lower respiratory ailments; and also a higher rate from digestive diseases among persons with bladder disorders in 1921-24. However, due to the size of the sample the higher rates could have been due to chance.

In summary, these data indicate that the great majority of persons that in 1921-24 had diseases such as cancer, tuberculosis, and the cardiovascular-renal group died of the same disease. For the more common diseases causing disability, such as rheumatism, neuritis, and the upper respiratory conditions, frequency of cause of death is no different from the expectations in persons without a chronic complaint at that time.

From the standpoint of discovering some factors which might be related to the development of causes of death, there is nothing to point to any of the more common disabilities as being associated with the development of tuberculosis and cancer. For the other causes of death stated, and especially for diseases of the heart, further study on a more extensive sample would be required to determine whether some of the differences noted above have real meaning.

DISCUSSION

From this analysis it is clear that in thinking about and discussing the problem of chronic ailments a distinction must be made between diseases such as cancer, tuberculosis, and the cardiovascular-renal group on the one hand, and conditions like neuritis, rheumatism, or respiratory diseases, on the other. The former in a sense stigmatize the individual; they become causes of death and increase the chances of an earlier death. The latter seem not to influence in any special manner either cause of death or survivorship, as observed after 20 years.

That persons with the latter ailments do not die any more frequently from any of the principal causes of death mentioned above (with the possible exception found in relation to heart disease), or at a greater rate than persons without a record of chronic ailments during 1921-24 is noteworthy. It could be inferred that these chronic conditions do not act as a forerunner to the principal fatal disease. One could also infer that the disability produced by the common chronic ailments does not affect mortality to any appreciable degree. Certainly, it does not seem to be associated with mortality to the same extent as body build, amount of work and other factors both environmental and genetic.

SUMMARY

In 1943 some 1800 white families who participated in the sickness survey conducted by the U. S. Public Health Service in Hagerstown, Md., 1921 to 1924, were investigated, and contact was made with 89 per

cent of the original group of families, and 83 per cent of the individuals alive in 1924. A first analysis of data obtained on 5375 of the 6220 individuals who belonged to families which were under observation for 26 months or more in 1921-24 reveals:

1. After nearly 20 years about 20 per cent of the individuals were found to have died.
2. Among persons between 15 and 50 years of age in 1923, those who had a record of some chronic disability, died at a higher rate than those with no record of chronic ailment.
3. However, the higher mortality of persons with chronic ailments occurred only for those with cancer, tuberculosis, and the cardiovascular-renal diseases. Persons with other kinds of chronic ailments and especially the more common ones such as neuritis, rheumatism, and respiratory conditions died in the twenty year interval at the same rate as persons of comparable age and sex with no chronic ailment in 1921-24.

ACKNOWLEDGMENTS

The author wishes to express his thanks especially to Dr. S. D. Collins who made available the original and derived records of the 1921-24 survey, and furnished valuable advice regarding them; to Miss Elizabeth Bell who conducted with zeal and enthusiasm the 1943 survey; to Miss Essie Chinto who was responsible for the clerical statistical work involved in the analysis of the data; to the officials of the Washington County Health Department and of the other public agencies that cooperated in the investigation.

THE RELATIONSHIP BETWEEN EPILEPSY AND MATERNAL AGE

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FROM discussions with Dr. Norma Ford Walker, of the University of Toronto, it appeared that certain characters of some epileptics corresponded to those commonly marking mongolian defectives but were in an opposite direction so that the possibility of a common type of developmental disturbance suggested itself. To press the correspondence so far as possible, it was decided to see whether the effect of maternal age, at delivery, for epilepsy was similar or opposite to that for mongolism. There was some immediate evidence for a similar influence of maternal age in the data of Penrose (1937) who found that the average age at which women were delivered of children subsequently appearing as epileptic, defective patients was somewhat higher than the corresponding average age for a general sample of defective children. Accordingly, it is proposed to discover how the probability that a birth will be that of an epileptic varies with mother's age, at delivery. The investigation follows the lines of the writers' (Beall and Stanton, 1945) work on mongolism, being based on a census of the number of patients by age and age of mother, at a given instant, in an institution. Appropriate data were obtained from the Ontario Hospitals at Woodstock (for epileptics) in August 1944, and Orillia (for defectives) in October 1944, as shown in Table 1. We are indebted to Miss R. Falk and Mr. H. Goodfellow, psychologists, respectively at the hospitals involved, for most kindly searching out and submitting the necessary data.

The data from Woodstock and Orillia are shown in Table 1 with grouping and restriction. The returns on mothers' age, by last completed year, are grouped in five-year periods; the returns on patients' age, to nearest completed year are similarly grouped. A first restriction was made to patients born since 1901. Of the remaining patients at Woodstock, 67 were excluded on the grounds that their epilepsy was

TABLE 1

Epileptic patients born since 1900 by their age and the age of their mother, at delivery

AGE OF MOTHER	AGE OF PATIENTS 0-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	Total
Patients Not Defective at Woodstock									
15-19	0	0	2	0	0	0	0	0	2
20-24	0	2	3	3	2	3	3	1	17
25-29	0	0	5	6	3	3	3	3	23
30-34	0	0	0	4	3	3	3	2	15
35-39	0	0	1	2	0	2	2	1	8
40-44	0	0	1	2	1	1	1	1	7
45-49	0	0	0	1	1	0	0	0	2
Total	0	2	12	18	10	12	12	8	74
Defective Patients at Woodstock									
15-19	0	1	0	1	4	2	2	1	11
20-24	0	0	5	6	6	6	1	3	27
25-29	0	1	3	6	5	3	5	4	27
30-34	0	1	3	5	5	6	3	3	26
35-39	0	0	1	3	2	6	2	5	19
40-44	0	0	1	1	0	5	1	0	8
45-49	0	0	1	0	1	0	0	1	3
Total	0	3	14	22	23	28	14	17	121
Morons at Orillia									
15-19	0	3	0	0	0	0	0	0	3
20-24	1	4	5	4	1	0	1	0	16
25-29	0	0	4	2	1	1	0	0	8
30-34	1	3	2	0	1	0	1	0	8
35-39	1	1	2	1	0	0	0	0	5
40-44	1	0	4	0	0	0	0	0	5
45-49	0	1	0	0	0	0	0	0	1
Total	4	12	17	7	3	1	2	0	46

TABLE 1 *(Continued)*

AGE OF MOTHER	AGE OF PATIENTS 0-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	Total
Imbeciles at Orillia									
15-19	0	0	4	0	2	0	0	0	6
20-24	0	5	11	6	0	2	1	0	25
25-29	4	2	11	6	3	3	2	2	33
30-34	1	10	8	4	6	1	3	0	33
35-39	3	4	6	4	2	1	1	0	21
40-44	0	0	1	1	2	0	0	0	4
45-49	0	0	0	0	1	0	0	0	1
Total	8	21	41	21	16	7	7	2	123
Idiots at Orillia									
15-19	0	1	1	0	2	0	1	0	5
20-24	10	10	6	2	1	2	1	1	33
25-29	4	9	8	4	3	5	1	0	34
30-34	2	8	6	6	2	0	3	0	27
35-39	4	4	5	2	1	2	0	0	18
40-44	1	0	0	2	1	0	0	0	4
45-49	0	0	0	1	0	0	0	0	1
Total	21	32	26	17	10	9	6	1	122

probably ascribable to trauma some time after birth or to infection. Of the patients at Orillia, 39 were excluded on the grounds that their epilepsy was complicated by various conditions—mongolism, foetal defect (hydrocephalus), hemiplegia or diplegia, microcephaly, and infective processes—which might be expected to be related, of themselves, to maternal age or else fairly clearly unrelated. The exclusions from the list for the two hospitals were made without regard for the observed maternal age at delivery so that, even in so far as they might be considered ill-judged, the exclusions should not contribute to any appreciable relation to maternal age subsequently found in the remaining data.

In Table 2, the percentage of patients by age of mother for each of the five groups, involved in Table 1, is shown against the proportion of births to women of various ages in 1921, which was about the middle of the period when the patients were born. The data for 1921 give the

TABLE 2

Percentage of patients with mothers in given age groups

AGE OF MOTHER	WOODSTOCK NOT DEFECTIVE	WOODSTOCK DEFECTIVE	ORILLIA MORONIC	ORILLIA IMBECILE	ORILLIA IDIOTIC	GENERAL POPULATION IN 1921
15-19	2.7	9.1	6.5	4.9	4.1	6.0
20-24	23.0	22.3	34.8	20.3	27.0	25.1
25-29	31.1	22.3	17.4	26.8	27.9	28.2
30-34	20.3	21.5	17.4	26.8	22.1	21.4
35-39	10.8	15.7	10.9	17.1	14.8	14.0
40-44	9.5	6.6	10.9	3.3	3.3	4.8
45-49	2.7	2.5	2.2	0.8	0.8	0.5

percentage age distribution of mothers that might be expected in a general sample of the population. Table 2 suggests that the epileptic patients had more mothers in the older age groups than the population generally. A rough measure of incidence of epilepsy on maternal age might be formed by getting the ratio of the numbers in the various columns to the figures for the 1921 general population. In view of recent rapid changes in birth-rates, as discussed for Ontario by Beall and Stanton (1944), it is obvious, however, that the results will vary with the arbitrary choice of 1921 or any other year and so it is preferable to make a more exact analysis.

In the present connection, there is used the method[1], devised by Beall and Stanton (1945), which consists of weighting the entries of Table 1 by the reciprocal number of women of various ages (in 1941) and by the reciprocal of the birth-rate of women for various ages at the time the patients were born. The procedure is illustrated numerically in an Appendix. This method takes into account the important fact that birth-rates in the past have varied materially from the 1941 figures. The birth-rate for the period 1921-41 is known and for the period 1901-21 is obtained

[1] The relative epileptic incidence for a given maternal age, m, is

$$z_m = \sum_{t=0}^{44} x_{mt}/N_{m3}\, Q_{mt}$$

where t is the age of a patient, x_{mt} is the number of patients of age t from mothers age m, N_{m3} is the number of women m years old in 1941 and Q_{mt} is the birth-rate for women of age m, t years ago.

by the extrapolation of a geometric progression, as discussed by Beall and Stanton (1944). The point of the present calculations is to replace numbers of patients by age and age of mother, as in Table 1, by some quantities so weighted that the cross-totals are independent. The cross-totals of numbers of patients in Table 1 were not independent. It must be emphasized that the viability of epileptics does not in any way affect this conclusion, if it be granted that the viability is practically independent of the age of the mother at delivery.

On the lines just indicated, the entries of Table 1 were weighted and totals, by age of mother, found as shown in the first panel of Table 3. A

TABLE 3

Relative epileptic incidences

AGE OF MOTHER	WOODSTOCK		ORILLIA			TOTAL
	Not Defective	Defective	Moron	Imbecile	Idiot	
			First calculation			
15-19	1.19	20.93	2.40	12.48	4.97	41.97
20-24	4.27	5.67	3.97	6.06	8.29	28.26
25-29	4.20	4.86	1.59	6.62	7.10	24.37
30-34	3.23	5.87	2.20	8.97	6.61	26.88
35-39	2.72	5.80	2.57	9.97	10.19	31.25
40-44	6.22	6.19	5.38	5.16	3.37	26.32
45-49	15.41	28.88	11.22	11.93	4.85	72.29
			On uniform basis of 1.00 for mothers 20-29 years old			
15-19	.28	3.98	.86	1.97	.65	1.59
20-24	1.01	1.08	1.43	.96	1.08	1.07
25-29	.99	.92	.57	1.04	.92	.93
30-34	.76	1.11	.79	1.41	.86	1.02
35-39	.64	1.10	.92	1.57	1.32	1.19
40-44	1.47	1.18	1.94	.81	.44	1.00
45-49	3.64	5.49	4.04	1.88	.63	2.75

second, corresponding, panel has been formed where the values are so adjusted that the average relative incidence for mothers in their twenties is 1.00; this adjustment facilitates the comparison of the various columns.

It should be borne in mind that the incidences in Table 3 are all *relative* to the other incidences occurring within a given column of a panel. The point to be considered is whether there is a departure from a constant probability of epilepsy for all maternal ages. There is a general indication in Table 3 that the probability of epilepsy increases with extremely high maternal age and possibly with very low. There is also a suggestion that the relation indicated, reminiscent of the situation obtaining for mongolism, is most acute for epileptics of superior intelligence. The figures of the second panel of Table 3 are presented diagrammatically[2] in Figs. 1 and 2.

The writers believe that it would be unwise to stress too much the apparent difference, as illustrated in Figs. 1 and 2, in the chance of epileptics of relatively high or low intelligence. Yet attention may be drawn briefly to the data of Dayton and Truden (1940) in Massachusetts where a considerable body of mentally retarded children was considered by a group of travelling psychiatrists. The number of children by degree of retardation and maternal age is shown in the first panel of Table 4. In the second panel of Table 4 the preceding figures have been reduced to percentages. No indication of a reduction in the proportion of children of low intelligence born by older women is apparent as suggested in Fig. 2.

The present study indicates that the probability that a birth will prove that of an epileptic, diagnosed probably idiopathic, is above normal for women in their late forties. The relationship is similar to that for mongolism, although more moderate. A correspondence of mechanism does not, of course, necessarily follow. The preceding effect had been anticipated but not a second difference in the incidence of epilepsy with the intelligence level of patients.

[2] The present illustrations are due to Mr. J. A. McClure of the Ontario Department of Health.

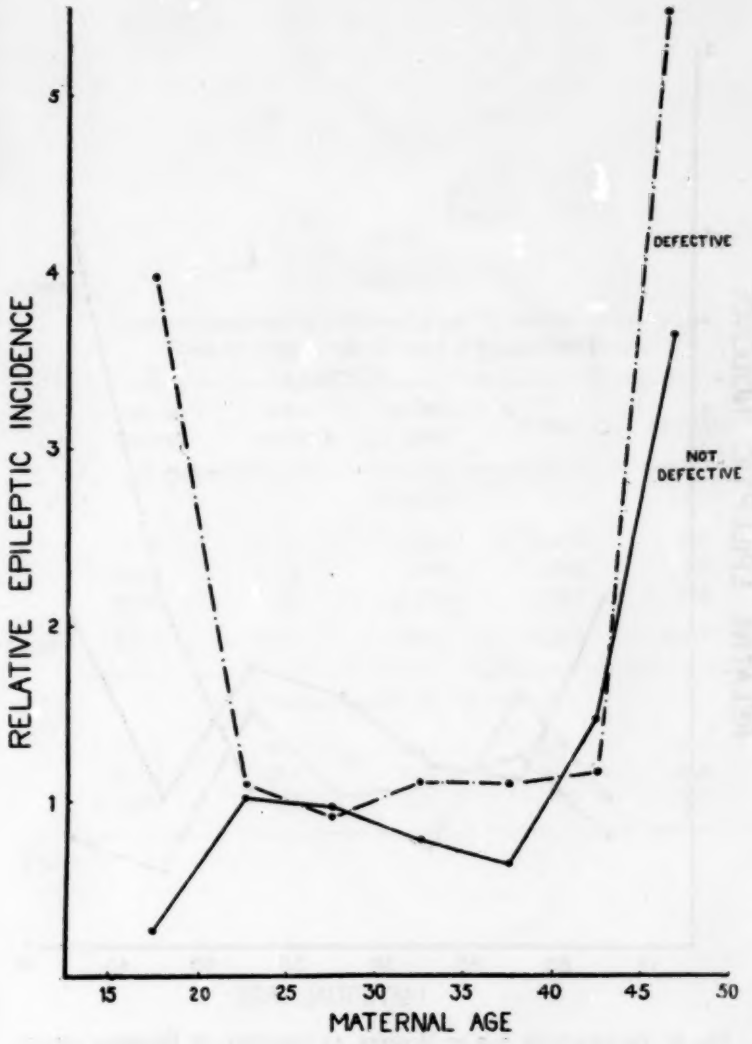

FIG. 1. EPILEPTIC INCIDENCE BY AGE OF MOTHER, AT DELIVERY, FOR PATIENTS AT THE ONTARIO HOSPITAL, WOODSTOCK

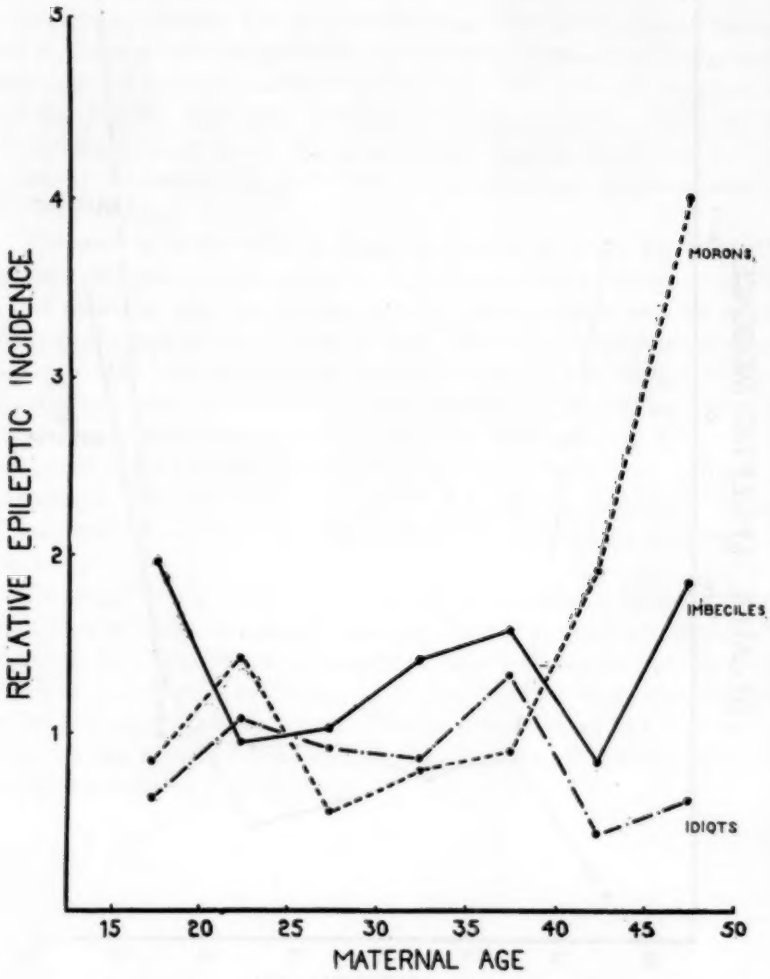

FIG. 2. INCIDENCE BY AGE OF MOTHER, AT DELIVERY, OF EPILEPSY AMONG THE PATIENTS OF THE ONTARIO HOSPITAL, ORILLIA

TABLE 4

Mental retardation in children by age of mother at delivery—Data of Dayton and Truden from Massachusetts

AGE OF MOTHER	DULL NORMAL	BORDER-LINE	MORON	IMBECILE
		Numbers		
15-24	1,550	3,377	4,076	286
25-34	2,677	5,116	5,866	468
35-50	1,050	1,954	2,231	254
Total	5,277	10,447	12,173	1,008
		Percentages by age of mother		
15-24	29.4	32.3	33.5	28.4
25-34	50.7	49.0	48.2	46.4
35-50	19.9	18.7	18.3	25.2

APPENDIX

To illustrate the calculations involved in the first panel of Table 3, they are made below, in detail, for males, not defective, at the Ontario Hospital, Woodstock, as shown in Appendix Table 1. This table shows the data—age t of patient in 1944 and age m of mothers at delivery, census figures, N_{m3}, or women m years old in 1941, and the estimated birth-rate, Q_{mt}, for women m years old t years before 1944. On these data the values, $10^8/N_{m3}\ Q_{mt}$ are found and summed for 5-year intervals. The results of the foregoing calculations when considered against maternal age are in the form of Table 3 or Fig. 2, where, however, the results are shown jointly for the sexes (not for a single sex, as in Appendix Table 1).

It may be pointed out that in Appendix Table 1, a value, $10^8/N_{m3}\ Q_{mt}$, such as .295, the second value, is in the first place, an estimate of

$$\int_{20}^{21} \int_{11.5}^{12.5} f_1(m)\, f_2(t)\, dt\, dm,$$

i. e., of the expected number of epileptics ($m=20$, $t=12$) divided by the appropriate census and birth-rate figures. Such quantities as that just estimated are of little direct value because they depend on two unknown functions. The sum, 1.490, of the second to the sixth values in Table 4, however, is an estimate of

$$\int_0^{\infty} f_2(t)\, dt \quad \int_{20}^{21} f_1(m)\, dm,$$

where the first factor may be regarded as an unknown constant. With limited data the estimates of the integral of $f_1(m)$ by single years are hazardous so that the estimates actually made are of a coarser integral with regard to m, i. e., of

$$\int_0^{\infty} f_2(t)\, dt \quad \int_{20}^{25} f_1(m)\, dm,$$

which is the sum of values the second to the ninth, i. e., 2.159.

APPENDIX TABLE 1

The calculation of the influence of maternal age for males epileptic, but not defective, and 43 years or younger at the Ontario Hospital, Woodstock

PATIENT'S AGE IN 1944, t	MOTHER'S AGE AT DELIVERY, m	NUMBER OF WOMEN m YEARS OLD IN 1944, N_{mt}	NUMBER OF CHILDREN PER 100,000 WOMEN m YEARS OLD t YEARS AGO. Q_{mt}	$10^5 / N_{mt} Q_{mt}$	SUM FOR 5-YEAR INTERVALS
16	18	33,454	5,050	.592	.592
12	20	32,546	10,405	.295	
14	20	—	10,390	.296	
20	20	—	10,348	.297	
33	20	—	10,257	.300	
43	20	—	10,187	.302	
28	21	32,298	12,034	.257	
22	22	32,066	14,642	.213	
29	22	—	15,640	.199	2.159
17	25	31,855	15,032	.209	
20	25	—	15,516	.202	
22	25	—	15,847	.198	
21	26	31,588	16,563	.191	
15	27	31,239	15,023	.213	
33	27	—	18,813	.170	
16	28	30,808	14,533	.223	
16	29	30,295	15,282	.216	
37	29	—	23,171	.142	1.764
26	30	29,269	14,434	.237	
39	30	—	17,119	.200	
41	30	—	17,574	.194	
20	32	28,157	13,007	.273	
21	32	—	13,281	.267	
24	32	—	14,137	.251	
38	32	—	18,921	.188	
40	34	27,148	19,234	.192	1.802
37	35	26,645	13,695	.274	
16	36	26,215	9,290	.411	
32	36	—	14,573	.262	.947
18	40	25,037	4,460	.895	
23	41	24,734	5,554	.728	1.623
25	45	23,358	991	4.320	4.320

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OSSICULA WORMIANA*

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AMONG the abnormalities of the human skull, metopism, according to our (Hess, 1) concept, does not represent a local peculiarity of the frontal bone. Based on an abnormal germplasm, it concerns not only the frontal suture, but it is likely to be associated in almost any instance with a group of signs, the "metopic syndrome," which on close examination can be recognized in the living patient. In this article we are dealing with another natural[1] anomaly of the human cranium confined in the majority of cases to its vault—the wormian ossicula—and with the epipteric bones which are similar to the former and may be associated with them.

As for the origin of these ossicles, it is essential to note that the majority of the wormian bones and, according to Morris (3), the epipteric bones in any case are preformed in membranes. The only exceptions to this rule are the very rare, wormian-like squamocondyloid bones which originate from cartilage. The ossa sphenofrontalia, mostly bilateral and symmetrical like many of the former, may not derive from cartilage but more likely from connective tissue (Augier, 4), although the question is a delicate one and not yet settled. The two ossicula mentalia at the lowest part of the symphysis mandibulae cannot be considered as wormian bones, although they develop from nuclei located in the membrane of the symphysis, because there is no sutureline separating the ossicula from the adjoining bones as we are accustomed to find in true wormian and in the epipteric bones. The os acetabuli which develops in the triradiate cartilage separating the three segments of the hipbone could be compared to the wormian bones since the sutures of the skull are homologous to the cartilages of the epiphyses. It is in any case

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[1] We do not take into account the wormian bones in artificially deformed crania (Dorsey, 2).

noteworthy that in skeletons with multiple wormian bones a persistent os acetabuli may be encountered. In cases of congenital hydrocephalus chondrodystrophicus (Dietrich-Weinnoldt, 5) at the borders of the parietal and frontal bones delicate fringes have been described which extend into the membranes between the bones. These structures cannot be grouped under the heading of wormian ossicula, the characteristic of which is a sutureline straight or delicately serrated at the circumference. Sometimes the wormian bone itself may be subdivided by a suture in two equal or unequal portions.

The conclusion we may draw is that there is, as in metopism, a certain change in the ossifying process of the mesoderm, mostly of the membranes, which underlies the formation of both the wormian and the epipteric bones. This change may be due to a metabolic disorder taking place very early in some skulls. Augier (6) noticed in a human embryo (v.c. = 180 mm.) in the lower part of the metopic suture some isolated osteogenic centers. In embryos of 68 to 92 mm. length he found an osteogenic center in the interlacrimo-maxillary space three times. This finding would lead us to surmise that the true wormian bones represent originally independent abnormal bones. But in other instances they might be considered rather as the product of nuclei detached from the main regular osteogenic centers. This second type, according to the literature, makes its appearance at a later date, perhaps post-partum.

As for the assumption of an altered metabolism, attention is called to the following facts: According to Chambellan (7), numerous wormian bones are met with not infrequently in congenital or early acquired hydrocephalus. Augier (6) observed four wormiana bregmatica in a newborn hydrocephalic baby. Fridolin (8) found a small sutural bone in the right lateral fontanelle of a hydrocephalus. The fonticulus anterior was closed by an oval wormian bone, in the anterior part of the right squamous suture there was a quadrangular ossicle, and in the upper half of the left coronary suture was a big wormian bone. The lower part of the inner border of the right nasal bone was connected with a small ossicle by a suture. In this condition as well as in the "lueckenschaedel" (Wieland, 30), and also in cases of encephalomyelo-meningocele, we are unquestionably confronted with an abnormal ossification either of the skull or of the vertebral column or of both of them. This abnormality is based on or at least closely connected with a central neurogenous factor as we shall see later.

More impressive are the findings in another pathologic condition of the skeleton, in the dysostosis cleidocranialis (P. Marie and Sainton, 9). As Léri and Tretiakoff (10) and also Crouzon (11) have pointed out, in any instance of this disease numerous wormian bones are met with. The presence of wormian ossicula may justly be considered as a characteristic feature of dysostosis. In this disease the occipital bone is highly underdeveloped, both clavicle bones are more or less atrophied or altogether missing, and all of the phalanges of the fingers shortened. In Paltauf's case (12) the alveolar process of the maxilla was missing. The mandible, according to Crouzon (11), is often weak. The multiple wormian bones thus represent a characteristic feature in a widespread or generalized anomaly of ossification. It is noteworthy from our point of view that the outer part of the clavicle bones ossifies out of membranes (Paterson, 13) at about the second month of embryonic life. At the same time the ossification of the membranous vault of the skull is starting. The upper part of the squamous portion of the occiput is originally membranous. In passing it may be mentioned that this interparietal portion of the os occipitale under normal circumstances, i.e. under circumstances when we are not able to recognize any pathological alteration, may be replaced by numerous ossicles or by a single large bone, the so-called "os preinterparietale." In the case of synostosis described by Paltauf (12), the parietal bone was divided into more than 150 small pieces, reminiscent in their appearance of wormian bones. A metabolic disorder of high degree in dysostosis is shown in this case beyond any doubt. The point we wish to stress is the multiplicity of the wormian bones, demonstrating at the best the condition *sine qua non* for their formation, i.e. the altered metabolism.

In one case of kebocephaly (Kundrat), Fridolin (14) noticed in the incisura parietalis of the temporal bone bilaterally a triangular wormian bone. The posterior fontanelle was closed by two triangular wormiana. The upper part of squama occipitalis, the crista galli, the lamina perpendicularis of the ethmoid, and the vomer were absent. There was a bilateral palatoschisis. Here we are again dealing with a widespread anomaly of the membranous bones associated with numerous wormiana.

In chondrodysplasia, where the morbid process concerns the hyaline cartilage and not the membranes, wormian bones have only been observed in the vault of the skull, the parietal and temporal bones being altogether spared from dystrophy. The skull in this disease is very similar to hydrocephalus.

Hypertelorism is another instance of disturbed development of a "cartilaginous" bone—the anterior part of the sphenoid. Here again numerous wormian bones are present, symmetrically arranged in the spheno-ethmoid, spheno-frontal, and fronto-ethmoid sutures, i.e. in areas where the bones derive from membranes (Greig, 15).

In all of the pathologic conditions where multiple wormian bones have been regularly noticed, the coincidence of metopism or the patency of many fontanelles or the presence of many abnormal openings in the cranial bones is remarkable.

In hydrocephalus, fontanelles and sutures are frequently patent. In the first case of dysostosis (9) the large persistent metopic suture was one of the most remarkable features. All fontanelles were patent in the adult patient. The first impression was that of hydrocephalus of high degree. Paltauf (12) noticed in his case asymmetry of the skull, a large defect in the middle of the frontal bone and rachischisis. Greig (16) observed a central depression corresponding to the frontal suture. Léri and Tretiakoff (10) saw metopism and all the sutures of the vault patent. Spina bifida was noticed by Klemmer (17), syringomyelia by Roussy and Ameuille (18). In Stewart's (19) case, all the fontanelles, the lambdoid, and the frontal sutures were patent.

In two cases of acrocephalosyndactylia, mentioned by Apert (20), an open suture running from the posterior fontanelle to the root of the nose was noticed. The frontal suture was large and patent. There were many abnormal openings in the frontal and both parietal bones. In one case of this disease there was observed a meningocele frontalis, palatoschisis, uvula bipartita.

In hypertelorism Greig (15) described, in addition to numerous wormian bones and two epipteric bones, an opening above the root of the nasal bones. The frontal suture was open, did not form digitations, and terminated above in a triradiate divergence. Huschke's foramina were open in both osseous meatuses.

Fridolin (21) mentions a case of trochocephalus-metopism, cleft of the right maxilla. In the middle of the suture between the palatal process of the right maxillary bone and the horizontal plate of the left palatal bone was a wormian bone. At the left side was the process of the maxilla, which forms the lacrimal groove, replaced by two small intersutural bones.

In case 3 of Brevicollis (Klippel-Feil syndrome) studied by Feller and Sternberg (22), the occiput was built up by three bones, the two

uppermost thoracic and the lower cervical vertebrae were composed of many ossicles, the arches split.

Erdheim (23) found in nanosomia pituitaria (male dwarf, 38 years of age) all the epiphyseal lines of the long bones, the vertebrae, sacrum, pelvis, basal fissures, the synchondrosis sphenooccipitalis, and all the sutures of the vault patent. The clivus bore at the floor a small opening. Remarkable for our conclusions was the presence of an os acetabuli on both sides and the separation of the epiphysis of the tuberositas ossis ischii into several segments. In the highly denticulated lambdoid suture there were numerous very small wormiana. In Apitz's (24) case of the same disease (male dwarf, 45 years old) the fissura spenopetrosa and petro-occipitalis, all the sutures of the vault and many epiphyseal lines were patent. There were four wormian bones in the lambdoid suture. In myxedema, with its profound metabolic disturbance, a persistent sphenobasilar line, metopism, and numerous wormiana were seen by Boncour (25).

In 44 crania with wormian bones, data on which are presented in Table 1, we found the metopic suture to be patent in 24 instances (54.5 per cent). In two crania (nos. 58636 and 59025) there was in addition an epipteric bone found to the right side. On the other hand, in morbid conditions with early closure of both the cranial sutures and fontanelles, (some cases of microcephaly, acrocephaly, and above all, scaphocephaly and oxycephaly), wormian or epipteric bones have never been reported. The trend to formation of wormiana on the one hand to premature synostosis on the other hand is apparently to some extent contradictory. It is noteworthy that in these latter conditions even normal openings may be narrowed. The orbital fissure may be contracted, the orbital cavities of unusually small size, the foramen lacerum and the jugular foramina exceedingly small (Greig), and there may be no condyloid canals and no parietal foramina formed.

Under normal conditions "premature" synostosis is frequent in the occipitomastoid suture (Toldt, 26: Bolk, 27), in the middle part of the coronary, in the sphenoethmoidal, internasal and nasomaxillary sutures. In all of these suturelines, wormian bones have rarely been encountered. The pterion-segment of the coronary and the asterion-segment of the lambdoid suture are the latest to start and the latest to complete their synostosis (Todd and Lyon, 28). These are the favorite locations of epipteric and of wormian bones respectively. The zygomaticotemporal suture closes at about 50 years of age. Here may be seen occasionally a

TABLE 1

Data on forty-four crania with wormian bones

SKULL NUMBER	PLACE WHERE FOUND	CIRCUMFERENCE	CEPHALIC INDEX	METOPISM	LOCATION OF WORMIAN BONES	ANGULUS CORONARIUS	LAMBDA	REMARKS
				a. Mesaticephalic skulls				
3152	Arizona St. Paul's South	44.4	74.6	Trace	Lambda-suture, r. and l.	Absent	Marked	Child, probably male. 10-11 years old. Occiput extremely flat. No asymmetry.
59172	Egypt Mesaed	48.2	76.2	+	Lambda and l. parieto-mastoidea			Lowest part of metopic sut. bulging.
6441	Italy, Campania Arpino	49.5	79.5	+	Above and below the lambda	Absent	+	Asymmetry of high degree (almost plagiocephaly). Glabella, inion, processus mastoidei, temporal processes strong.
60675	New Mexico Pecos	46.5	75.0	+	Both coronary sutures and at bregma	Coronary suture markedly convex	None	Marked asymmetry of occiput. Crista supra meatum, glabella, temporal processes strong. Lambdoid suture long-toothed except for the most lateral segments.
1076	?	50.2	76.8	+ Sagittal open	Lambda	Almost 180°	None	Marked asymmetry of occiput. Forehead low, occiput very flat, its median part depressed.

TABLE 1 *(continued)*

SKULL NUMBER	PLACE WHERE FOUND	CIRCUMFERENCE	CEPHALIC INDEX	METOPISM	LOCATION OF WORMIAN BONES	ANGULUS CORONARIUS	LAMBDA	REMARKS
				b. Dolichocephalic skulls				
57967	New York	47.0	70.1	—	Lambda	Almost 90°	None	Wormiana slightly depressed. Occiput extremely prominent.
3855	Bolivia Warizata	42.0	70.5	—	4 to the r. lambda suture; Inca bone (divided)	Convex	None	Prominence in front and beinind the bregma. Proc. mastoidei and cristae supramast. big.
3850	?	47.0	66.6	Traces	Lambda	Almost 90°	Very flat	Remains of metopic slightly ridged defect in the l. parietale and in occiput.
59595	Canary Islands Tenerife Hoya Grande	49.1	71.0	+	3 to the r., 2 to the l. Lambda sut.	Very slightly convex	None	Above the l. pterion a depression. Occiput asymmetrical, bulging. Proc. mast. and cristae supramast. big.
15271	Hawaii Mani	?	?	+	Inca divided; 2 small to the l.; one bigger to the r. Lambda sut.	Cor. very asymmetrical	None	Fragile. R. temple broken. Asymmetry of high degree.
1118	?	46.5	66.4	—	Lambda, r. and l.	No. almost 180°	None	No asymmetry, median part of occiput depressed, lowest segment protruding.

TABLE 1 *(continued)*

SKULL NUMBER	PLACE WHERE FOUND	CIRCUMFERENCE	CEPHALIC INDEX	METOPISM	LOCATION OF WORMIAN BONES	ANGULUS CORONARIUS	LAMBDA	REMARKS
26597	?	50.0?	68.8	—	Lambda, r. side	Almost 180°	None	Skull broken. Forehead low, with a depression to the r. side.
59894	New Mexico, Pecos	45.6	66.4	—	Lambda	Slightly convex	None	No asymmetry. Traces of sut. incisiva.
57576	Ohio Madisonville			+	Lambda	Almost horizontally 180°	None	Skull incomplete, right side of glabella and left tuber parietale protruding. Lambda suture long-toothed.
58104	New York	49.7	69.3	—	Lambda	Almost 180°	None	No asymmetry. Ext. occiput. protuberance marked.
58636	Oric Bates	53.0	62.1	+	Lambda and epipterion to the r. side	Almost 180°	None	Behind the r. processus condyl. a deep depression.
58705	Africa Siwa Oric Bates	52.0	56.9	+	Lambda and 2 at the l. side	Almost 180°	None	Traces of bathrocephaly.
845	Egypt	53.3	62.0	+	Lambda, numerous to the r. and l. side	Almost 180°	None	Young subadult male (of 18 years). Healed lesion on r. half of frontal bone (due to fracture).

TABLE 1 *(continued)*

SKULL NUMBER	PLACE WHERE FOUND	CIRCUMFERENCE	CEPHALIC INDEX	METOPISM	LOCATION OF WORMIAN BONES	ANGULUS CORONARIUS	LAMBDA	REMARKS
59254	Egypt Skeikh Fanag (Middle Empire)	48.2	58.6	+	Coronary to the l.	Very slightly convex	Markedly acute	Occiput extremely flat. Bregma and l. half of coronary bulging.
6442	Italy Campania Arpino	53.1	69.6	+	Lambda sut., to the r. and l. Inca bone (divided)		About 90°	Ant. part of sagittal sut. prominent, big proc. mast. and cristae supramastoideae. Forehead low.
59557	Canary Islands Tenerife Guauche Burial	50.0	72.2	+	Lambda and lambda sut., to r. and l.	Slightly convex	Almost none	Facies absent. Bony prominence to the l. post. border of for. occ. magn. R. parietal bone more prominent.
59591	Canary Islands Tenerife Cave near Arafo	50.3	70.0	+	Lambda (more to the l.)	Almost 180°	Very flat	Lambdoid suture throughout long-toothed. Occiput asymmetrical. Ridge in front of basion at basilare. Occiput extremely bulging. Big mastoids and cristae supramastoideae.
58708	Africa Libyan Desert Cemetery	48.3	61.3	+	Above the l. mastoid	Almost horizontal	Arch instead of angle	Tubercle in front of basion at basilare. Asymmetry of occiput marked.

TABLE 1 *(continued)*

SKULL NUMBER	PLACE WHERE FOUND	CIRCUMFERENCE	CEPHALIC INDEX	METOPISM	LOCATION OF WORMIAN BONES	ANGULUS CORONARIUS	LAMBDA	REMARKS
59732	Ohio	51.0	64.5	—	To the l. of lambda, 2 wormian	Coron. suture convex but at its central part	None	Forehead low.
26597	?	50.0?	68.8	—	To the r. side, behind and above the mastoid	Almost 90°	None	Skull broken.
58698	?	50.5	63.5	—	Inca; to the r. Lambda sut.	Almost 90°	None	
59025	Upper Egypt Keneh Predynastic	50.5	67.4	+	R. sut. parietomastoidea and r. epipterion			Marked asymmetry of occiput. Forehead low.
201	Africa Morocco Preislamic	51.5	65.8	+	To the r. and l. lambda sut., the l. divided	Almost 90°	None	Cribra orbitalia.

TABLE 1 *(continued)*

TABLE 1 *(continued)*

SKULL NUMBER	PLACE WHERE FOUND	CIRCUM-FERENCE	CEPHALIC INDEX	METOPISM	LOCATION OF WORMIAN BONES	ANGULUS CORONA-RIUS	LAMBDA	REMARKS
59254	Egypt Skeikh Fanag (Middle Empire)	45.5	59.2	+	Epipterion to the l.	About 90°	None	
57916	Iceland	49.0	61.9	+	2 small to the r., one to the l.	Almost 180°	None	Female. Divided inca bone, small exostosis on the r. side of palate. Opening behind the r. mastoid. L. parietal flat.
57913	Iceland	48.5	66.0	+	Numerous small at lambda, epipterion to the r.	Slightly convex	None	Marked asymmetry of occiput. Protuberance behind the bregma.
58097	New York	51.0	67.7	—	Lambda to the l.	Slightly convex	Very obtuse	R. squama tempor. broken. In the middle of the closed frontal sut., a thickening.
3082	?	52.0	68.1	—	One at the center of lambda, 2 to the r., 1 to the l.	Slightly convex	Very obtuse	No asymmetry. Glabella and cristae supramastoideae prominent. Lower occ. slightly bulging. L. wormian bipartit.
3094	?	52.8	68.1	—	3 to the r., 2 to the l. of lambda at the meeting point of sut. squamosa and sphenopariet. to r. and l.	Slightly convex	None	Sagittal sut. slightly prominent. Big mastoid. proc.

TABLE 1 *(continued)*

SKULL NUMBER	PLACE WHERE FOUND	CIRCUMFERENCE	CEPHALIC INDEX	METOPISM	LOCATION OF WORMIAN BONES	ANGULUS CORONARIUS	LAMBDA	REMARKS
3835	?	48.4	67.0	—	Lambda	Slightly convex	None	Hole in occiput, l. zygoma broken. Big ridge in front of basion.
58821	Upper Egypt Keneh Predynastic	46.2	60.8	Trace (lowest part)	Lambda	Convex	More than 90°	Skull asymmetrical. Occiput thickened around the mastoids.
59896	New Mexico Pecos	42.5	64.2	Trace (lower than glabella)	Lambda to the r.	Almost 90°	None	Dehiscence of both tympanic plates. Asymmetry of high degree. Bony thickening around the l. pterion.
59370	Marblehead, Mass.	47.0	60.0	+	Lambda and to the r. and l. numerous	Almost 90°	Almost none	Marked asymmetry.
1257	New Hampshire Effingham	46.5	64.7	+	Lambda more to the r. at metopic sut. near the naso-frontal sut.	90°	Flat	R. coronary lies behind the left. Protub. occ. ext. deviates to the l.
55918	New Mexico Pecos	49.1	71.7	+	Lambda	Almost 90°	None	Plagiocephaly. Occiput flat.

TABLE 1 *(continued)*

SKULL NUMBER	PLACE WHERE FOUND	CIRCUM-FERENCE	CEPHALIC INDEX	METOPISM	LOCATION OF WORMIAN BONES	ANGULUS CORONA-RIUS	LAMBDA	REMARKS
				c. Brachycephalic skulls				
7160	Peru	49.0	81.2	+	To r. and l. of lambda sut.	Slightly convex	Flat	Asymmetry of high degree. Metopic suture open and slightly bulging. Occiput extremely flat.
59405	Peru Pacha-camae	45.8	93.1	+	Lambda	Marked asym-metry of both halves of coron. sut.	Marked	Asymmetry of high degree. Exostosis at basion. Osteoma to the r. temporal arch. Canalis hypoglossi bipartit.
1113	?	44.8	80.7	—	One at bregma, big quadrangu-lar; to the r. pterion; some to the l. lambdoid sut.	Cor. slightly convex	Very flat	Lambdoid sut. long-toothed and as a whole depressed, whereas surrounding bones are thickened. Occiput very flat. Frontal bone slightly depressed to the r. and to the l. Many sutures open, particularly both occipitomast. and both pteria.
1098	Arizona G. of Gila Pueblo	49.8	82.9	+	At the sut. parieto-mastoid. to the l.	Cor. slightly convex	None	Metopic sut. bulging and not entirely closed. Sut. squamosa very irregular. Parietale and occiput flat, mostly at the l. Marked asymmetry.

small bone of irregular shape, separated by a suture reminiscent of a wormian ossicle (Gruber, 29). This is a rare instance of a wormian-like structure in the skeleton of the human face, whereas in animals it is more common in the visceral cranium. The metopic suture when persistent may stay open up to an advanced age. I personally observed some few cases of metopism in elderly patients of between 60 and 75 years of age. This is not without interest in regard to life expectancy. The occurrence of a metopic bone, homologous undoubtedly to a wormian bone, has been noted in the literature. In one of our cases (no. 1257) in addition to a wormian to the right half of the lambdoid suture, an ossicle in the lowest part of the dehiscent metopic suture near the nasofrontal suture was noticed.

One gains the impression that there might be a relation between the growth of the skull and the wormiana. Zuckerkandl, as was mentioned in our article on metopism (1), noticed many years ago that there are certain skulls remarkable because once one of their sutures is closed the others are prone to close also in a short time. He made the observation that in oxycephalic skulls the early closure of the sutures "in regione temporali" is common, followed by the closure of all the other sutures of the skull. This statement was later confirmed by Greig (30). In true oxycephaly a constant and characteristic feature is the want of sutures throughout the whole of the skull, exclusive of the mandible. In these crania wormian bones are never present. Nevertheless, there are certain crania where the tendency to synostosis is localized, as in the skull described by Fridolin (8) (boy, three months old, plagiocephalus with the right half of the coronary suture in its upper segment closed, stenocrotaphy with the right ala magna of the sphenoid extremely narrowed, the right frontal and parietal eminences missing, and the right zygomaticomaxillary suture likewise closed). In this case a big intersutural bone was found in the fonticulus frontalis, subdivided by a suture into two portions. Furthermore, to the right side of the squama occipitalis there was a big triangular bone (os triquetrum). This skull will be discussed later.

From the physiological point of view, it is necessary to bear in mind that in normal synostosis three stages are to be differentiated: (1) stoppage of cartilaginous growth, (2) vascularization and replacement of the cartilage by connective tissue, and (3) ossification of the latter. In cases where the epiphyseal lines of the long bones stay open, all three of these processes have been simultaneously blocked. When cranial

sutures remain open, the growth of the interstitial connective tissue and the marginal apposition of the bone are simultaneously blocked. In addition to this, in some crania accessory ossifying centers may come into existence and thus give rise to wormian or epipteric bones. From a broader point of view, it is not without interest to note that certain sutures, physiologically characterized by their late closure, constitute the favorite location of the abnormal ossicles under discussion.

The association of wormiana with spina bifida, metopism, syringomyelia, and abnormal openings would lead us to suggest that these phenomena be subordinated under the larger category, "hypostosis." This broad category would include:

(1) Lueckenschaedel (Wieland, 30), Weich—, Reliefschaedel (M. B. Schmidt, 31)
(2) Metopism
(3) Hydrocephalus congenitus
(4) Status dysrhaphicus (spina bifida, syringomyelia, hydromyelia, encephalo-myelocele, heterochromia of iris (Hess, 32), cryptorchidism (Hess, 33)
(5) Klippel-Feil syndrome (Feller-Sternberg, 22)
(6) Dysostosis cleidocranialis
(7) Osteogenesis imperfecta
(8) Sprengel's deformity, sometimes associated with defect of spine (du Toit, 34)
(9) Palatoschisis or cheilognathopalatoschisis
(10) Kebocephaly
(11) Wormian and epipteric bones

In order to clarify the meaning of these ossicles it is necessary to give some of the details of the skulls involved.

TENDENCY TO ASYMMETRY

In our (Hess, 1) studies on metopism we arrived at the conclusion that metopism is frequently associated with asymmetry of the cranium and with many bony anomalies. On the other hand, as we have seen, and according to the literature and our observations, metopism may go together with formation of wormian bones. In cases of dysostosis studied by Paltauf (12) and by Raubitschek (35), there was marked asymmetry of the hemispheres of the brain. Striking was the asymmetry of the basal ganglia in Stewart's observation (19). In hypertelorism

signs of asymmetry are well-known. The same holds true of plagiocephalus and trochocephalus (Fridolin, 8).

The lack of symmetry and the finding of numerous wormian bones favor the suggestion of an anomaly of cranial growth. Whether this is due to an abnormal germplasm or to a metabolic disorder acquired in early embryonic life cannot be stated.

THE OCCIPITAL BONE

In dysostosis, the classical condition where numerous wormiana are regularly to be seen, the occiput is flat, highly underdeveloped. In hypertelorism foreshortening of the squamous portion is a salient feature. The chondodystrophic skull is characterized by the short floor, and the synchondrosis sphenooccipitalis closes early. In acrocephalosyndactylia the occiput again is flat and very small. Extreme flatness was noticed in 7 (15.9 per cent) of our skulls.

THE SPHENOID BONE

Underdevelopment of the greater wings and of the pterygoid processes has been noted in dysostosis, hypertelorism, chondrodystrophia. Smallness of the occiput, early synostosis of sphenooccipital synchondrosis, or malformation of the sphenoid would lead to brachy- or hyperbrachycephaly, with the lower part of squama occipitalis often bulging. This so-called "bathrocephaly" associated with numerous wormiana has been observed in Swiss crania. Persens found it in 8.6 per cent of skulls from Kent (belonging to the 14th century). From the mechanical viewpoint it is obvious that in order to get sufficient room for the expansion of the brain, when the sagittal diameter of the cranial cavity is diminished, an increase of its transverse diameter is required. This would point to a compensatory function of the wormian ossicles and would explain their more frequent occurrence in the lateral parts of the skull. Consistent with these facts would be the old view held by Ranke (36) that wormian bones are the result of increased intracranial pressure during the period of growth. The following brief review from the literature, as far as the cephalic index is concerned, might plead in the same sense:

CEPHALIC INDEX (NORMA VERTICALIS)

Dysostosis cleidocranialis	85, 8-89, 7 (Hultkrantz, 37)
Nanosomia pituitaria	83, 8 (Apitz, 24)
Hypertelorism	77, 0-82, 0 (Freak, M. B. Allen, 38) (Greig, 15)
Kebocephaly	Skull short, large
Chondrodystrophy Hydrocephalus	Skull large, broad; figures cannot be given on account of various amounts of liquid within the cranial cavity.

Our studies, however, provide evidence that in dolichocephaly and even in hyperdolichocephaly (cephalic index from 56.9 to 69.6) wormian bones may be seen. Furthermore, there is no doubt that wormian and epipteric bones can be detected in skulls of normal size and shape. They may be arranged, as Rokitanski (39) noticed in these "normal" skulls in two or three chains, with sutures between them and the bones adjoining. We may infer that there is no connection between the cephalic index and the wormiana.

The angle formed between sagittal and coronary sutures (angulus coronalis) is known to measure on the average about 106 degrees. The two segments of the coronary are usually not found in a horizontal line, but form an obtuse angle which opens anteriorly. *A priori* it is to be expected that the more the lower and lateral parts of the frontal bone are developed, the more the coronary suture might be forced into a transverse direction. We observed in 21 of our cases (i.e. 47.7 per cent) the coronary to be almost horizontal. The cephalic index ranged between 59.2 and 74.6. Noteworthy in this group was the high percentage of metopism (13 cases or 61.9 per cent) combined with the horizontal coronary. We are inclined to draw the conclusion that the coincidence of asymmetry, metopism, and horizontal course of the coronary suture is frequent in skulls with wormiana. In some of the crania the forehead gave the impression of being extremely low (12 cases or 27.3 per cent). In many skulls with the horizontal course of the coronary, the "lambda" was almost missing and replaced by a curved line with the convexity anteriorly. Only when the occiput was extremely flat or highly asymmetrical (nos. 3152, 59254, 59405) was the angle found to be preserved.

It is amazing and, from a clinical or biological standpoint, interesting that the formation of numerous wormian ossicles is an almost constant feature in cases with profound congenital abnormalities of the central nervous system (see Table 2).

TABLE 2

Conditions with multiple wormiana, and associated anomalies of the central nervous system

CONDITIONS WITH MULTIPLE WORMIANA	ANOMALIES OF CENTRAL NERVOUS SYSTEM
Dysostosis cleidocranialis	Asymmetry of hemispheres Syringomyelia Cyst in the occipital lobe
Hydrocephalus congenitus	Encephalocele Porencephaly
Acrocephalosyndactylia	Meningocele frontalis. Underdevelopment of occipital lobe
Klippel-Feil syndrome	Underdevelopment of cerebellum Smallness of cervical spine
Nanosomia pituitaria	Growth of pituitary duct Craniopharyngeoma

"Hypostosis" on one side, lack of normal closure of the neural tube or other malformations of the central nervous system on the other side, would go together. There is universal consensus that the development of the labyrinth and that of the cartilages and bones of its capsule are connected. Also, an intimate connection appears to prevail between the trend to formation of wormiana (or, in a broader sense, to "hypostosis") and certain abnormalities of the central nervous system.

SUMMARY

(1) Formation of wormian and epipteric bones is related to a metabolic disorder of the mesoderm.

(2) Asymmetry of the skull, malformation of certain bones (occiput, sphenoid bone), absence of angulus coronalis, and metopism are frequent in skulls with wormian bones.

(3) Noteworthy is the coincidence of numerous wormian bones with congenital anomalies of the central nervous system.

(4) Under the heading "hypostosis" many abnormalities of the skeleton, including the wormian and epipteric bones, can be summarized.

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